MISC. PAPERS, PUBLICATIONS AND LECTURES I

COSMIC REPLICATION OF ATOMIC PARAMETERS

Albert G. Wilson

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Either some process is operative in the formation of higher order aggregates which reflects atomic constants, or there exists some basic universal property of all structures which relates them to the dimensionless constants observed in both atomic and cosmic physics. In the second case, the constants may be "trans-physical", possibly of number theoretic origin.

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Albert G. Wilson

(Paper read A. I. P., Ober Wolfach, July, 1966)

ABSTRACT

An upper bound to the ratio of gravitational energy to total energy of non-degenerate cosmic bodies has been observationally established. The ratio of the non-degenerate bound to the relativistic bound predicted by Schwarzschild is equal, to within observational uncertainties, to the basic atomic structural ratio, α^2, with α being the Sommerfeld fine structure constant. While the occurrence of this ratio between non-degenerate and totally degenerate states may be readily explained in the case of stars (since stellar degeneracy is defined on the basis of atomic structure), it is difficult to account for the appearance of the same ratio in larger aggregates - galaxies, clusters, second-order clusters.

Either some process is operative in the formation of higher order aggregates which reflects atomic constants, or there exists some basic universal property of all structures which relates them to the dimensionless constants observed in both atomic and cosmic physics. In the second case, the constants may be of "trans-physical", possibly of number theoretic origin.

Being neither a physicist nor a philosopher, but speaking as an observer, I want to re-emphasize Prof. Flugge's remarks that our goal is not simply the accumulation of data, but achieving an organization of the emerging basic relationships. This is sometimes lost sight of in certain quarters and we view with alarm the warehouses full of magnetic tapes of data - all unreduced.

Speaking as an astronomer, I would like to insert a modification into Prof. Noll's trilogy of

experience - theory - experiment

observation → theory → (theory directed observation)

ab initio observation being all too often neglected.

And I also want to acknowledge that observational astronomers know all to well what Prof. Tornebohm means by <u>low grade knowledge</u>.

COSMIC NUMBERS

Albert Wilson

INTRODUCTION

The purpose of this paper is to make two observations concerning the so-called cosmic numbers and to discuss briefly some of their philosophical implications. The first observation is the occurrence of the cosmic numbers in the structure of physical aggregates ranging in scale from atoms to clusters of galaxies. The second is that the numbers are representable by simple expressions containing only basic mathematical constants.

PART I

A feature of the physical world that is repeatedly observed in the microcosmos, the mesocosmos, and the macrocosmos is likely to be a manifestation of the basic structure of the universe. Such a feature holds possible clues to the foundations of the natural order. The so-called cosmic numbers, or dimensionless constants of physics, such as the Sommerfeld Fine Structure Constant, $\alpha = \frac{2\pi e^2}{hc}$, and the ratio of Coulomb to gravitational forces, $S = \frac{e^2}{Gm_p m_c}$, have numerical values that occur frequently in dimensionless combinations of observables measured not only in atoms but in material aggregates of all sizes. If the numerical reoccurrence of these values may be taken simply as an observed phenomenon, their frequency of occurrence implies their fundamental significance and any ultimate construct or cosmological model which successfully represents the physical world will have to contain and account for these numbers.

In this paper, I shall not give a history of the numbers nor go into the interpretations which have been given to them by Eddington, Dirac, and others. I plan to limit myself as much as possible to the empirical aspects of the numbers. The experimental values adopted by DuMond and Cohen (1965) for $\alpha^{-1} = 137.0388$ and $\log_{10} S = 39.356$, the latter number possesses uncertainty in the last place because of their relatively inaccurate knowledge of the gravitational coupling constant, G.

It is well known that numbers of the order of 10^{40} occur in cosmology. For example, the ratio of the "Hubble Radius of the Universe" c/H to the radius of the electron $e^2/m_e c^2$ is $10^{40.5}$. Sometimes the square of this quantity occurs. Eddington's "number of heavy particles in the universe" is observationally

$$\frac{\rho_o (c/H)^3}{m_p} = 10^{78} = (10^{39})^2$$

These instances of the numbers have been speculated over for some four decades and have been widely discussed without any conclusions being reached. I would like to point to some additional occurrences of these numbers that have not been reported until recently (Wilson, 1966). The first table gives the maximum observed values of the potentials of four species of cosmic aggregate - stars, galaxies, clusters, 2' clusters.

It is seen that each of these potentials, when expressed in dimensionless form, i.e., with respect to M_H/a_o, is again a number of the order of 10^{39}. This is true for stars ($R = 10^{11}$cm), Galaxies ($R = 10^{22}$cm), Clusters ($R = 10^{25}$cm), 2° order clusters ($R = 10^{26}$cm). (It may also be true for Quasars if Smith's values for the periodicities in light fluctuation have a conventional interpretation.) This result is especially interesting since the technique of measuring the potentials is different in each case and does not depend on a distance scale. Dirac held that that the repeated occurrence of a number of this magnitude can hardly be attributable to chance. If we spin an epistemological roulette wheel and come up with this number six times, the probability of this is, say, $1/n^5$, where n is the number of numbers on the wheel. If there are a large number of numbers, i.e., if n is large - then this is not a chance coincidence. If n is small, then this itself would be an even more remarkable fact about the universe.

Dirac postulated as a "principle" that all of these large dimensionless numbers which occur in physics are the same, or differ from each other at most by some simple factor of the order of unity such as 2 or π, etc. Let us assume that this is a valid principle and that these numbers are the same if we but knew the proper factor of the order of unity to insert. (Our errors are of the order of 2 or π anyway.) If then we say these numbers are equal to S, with $\log_{10} S = 39.356$, we have $\log_{10} \frac{M_N}{R_N} = 23.856$ and

$$\log_{10} \frac{GM_N}{c^2 R_N} = -4.274 = \log_{10} \alpha^2.$$

That is to say that the observed bound on the value of the ratio of the gravitational radius to the linear radius for all observed non-degenerate cosmic aggregates is α^2, which is the same as the ratio of the first Bohr radius to the electron radius. So it appears to within the relatively small errors of measurement that both α and S occur at the scales of all bodies observed in the cosmic hierarchy.

The Schwarzschild Limit states $\frac{GM}{c^2 R} < \frac{1}{2}$

The observed limit is $\frac{GM}{c^2 R} \leq \alpha^2$ or $\frac{\alpha^2}{2}$, etc.

This may be alternatively interpreted that the highest velocity any bound or attached material body may have is αc, whether this is the speed of an electron in the first Bohr orbit or the escape velocity from a star, galaxy, cluster, or whatever.

I do not intend to discuss here the physics or astrophysics of this ratio which states that

$$\frac{\text{gravitational radius}_N}{\text{linear radius}_N} = \frac{\text{nuclear dimensions}}{\text{atomic dimensions}}$$

I only want to draw attention to the reoccurrence of the quantities α and S.

We may portray this graphically in Figure 2.

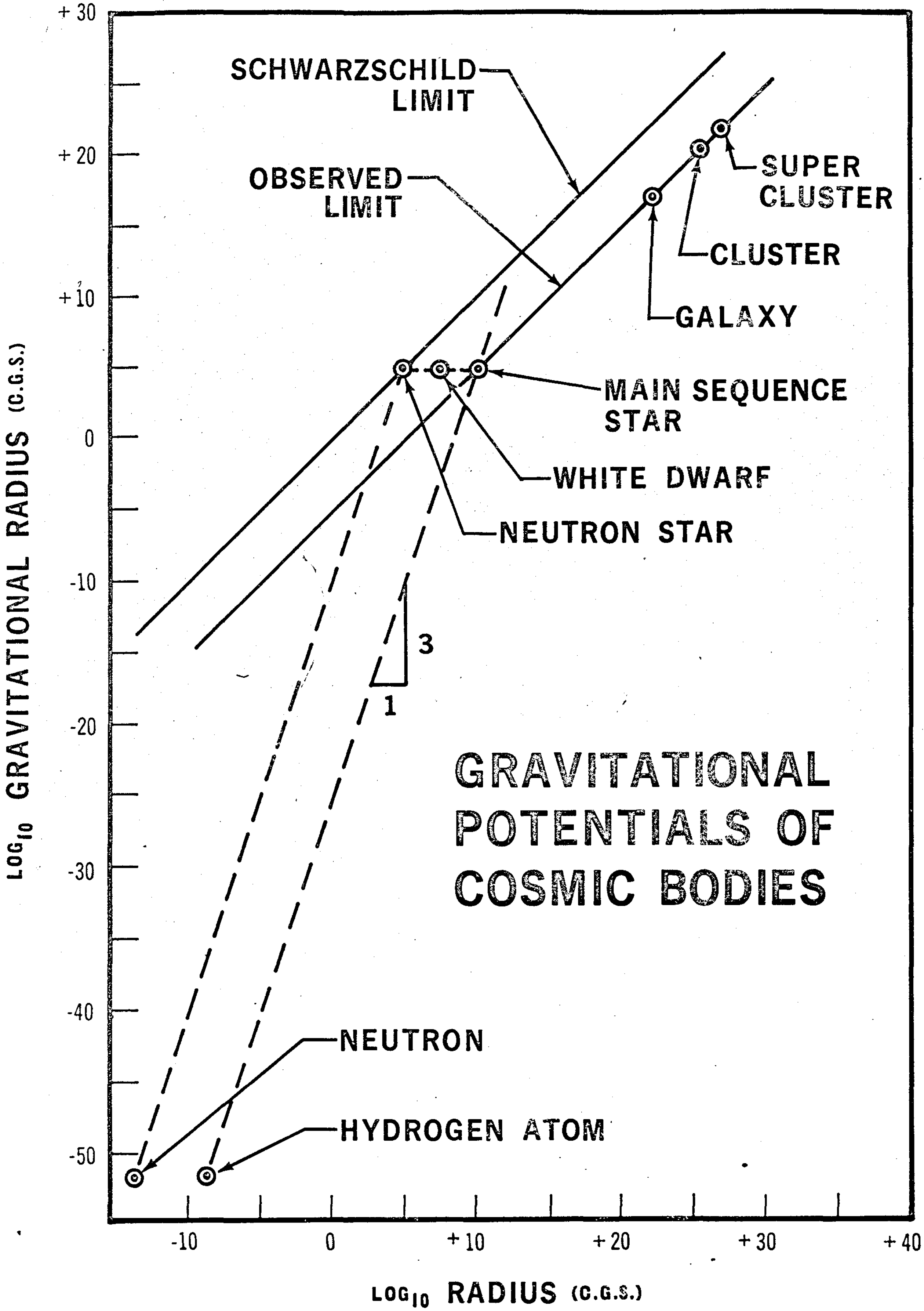
Now, we are faced with what may be interpreted as a set of numerical coincidences or numerical curiosities which like other such curiosities, e.g., the Titius-Bode Law, are to be filed away until some future time when a theoretical construct can be built out from existing knowledge to encompass these oddities. If we hold the existing body of knowledge as that which is interpretable in terms of The Theory (in the sense of Max Born), these oddities lie definitely outside the pale.

However, there seem to be enough of these detached pieces which fit together that it may be possible to build the bridge in both directions. Before this we must be concerned with two things: first, are these detached pieces part of the real puzzle - and it seems likely (by paradigmatic inference) that they do belong to the same picture that The Theory is developing. If we are reasonably certain of this, then secondly, can we synthesize from the "low grade" knowledge which these detached oddities provide and actually begin to construct on them, i.e., make predictions from them. In other words, may we develop hypotheses spanning inward.

What, if anything, can be said at this time which will allow us to develop testable hypotheses. We might re-examine the "Conjecture of Eddington" - that the cosmic numbers and other constants are expressible in mathematical constants; in view of the fact that as of now most of the fundamental constants of physics have been measured with sufficient accuracy to make a re-examination worthwhile.

SUMMARY OF OBSERVATIONS

SYSTEM	$\log_{10}[R]$ (c.g.s.)	$\log_{10}[M]$ (c.g.s.)	$\log_{10}[M/R]$ (c.g.s.)	$\log_{10}[M/R]$ (dimensionless)
HYDROGEN ATOM	−8.27640	−23.77642	−15.50002	$\times 5 = 23.8$
STARS				$\div \frac{G m_0^2}{\ell_0}$
V444 CYG A	11.185	34.457	23.272	38.8
40 ECL. BINARIES	11.541	34.205	22.664	
SUN	10.843	33.299	22.456	
GALAXIES				
M87	22.3	45.9	23.6	39.1
M31	22.2	44.8	22.6	
7 GALAXIES	--	--	22.6	
MILKY WAY	22.26	44.30	22.04	
CLUSTERS				
COMA	25.95	49.40	23.45	39.0
7 CLUSTERS	--	--	22.59	
4 CLUSTERS	25.54	48.08	22.54	
SECOND-ORDER CLUSTERS				
ABELLIAN CELL	26.0	49.2	23.2	38.7
LOCAL SUPER-CLUSTER	25.7	--	--	


GRAVITATIONAL POTENTIALS OF COSMIC BODIES
SCHWARZSCHILD LIMIT
OBSERVED LIMIT
SUPER CLUSTER
CLUSTER
GALAXY
MAIN SEQUENCE STAR
WHITE DWARF
NEUTRON STAR
NEUTRON
HYDROGEN ATOM
3
1
+30
+20
+10
0
-10
-20
-30
-40
-50
+40
LOG10 GRAVITATIONAL RADIUS (C.G.S.)
LOG10 RADIUS (C.G.S.)

PART II

Eddington held that the dimensionless physical constants could be evaluated as simple mathematical expressions. His approach to this conjecture was through a construct established by purely rational arguments from which the values of the dimensionless physical constants could be derived solely by mathematical inference (1). His success in proving his conjecture by means of the fundamental theory has been questioned. The difference, for example, between the derived 137 (2) and the observed 137.0388 (3) is considered by some to be unsatisfactory in view of the essential claim to derive the observed world from first principles. However, because of the philosophical implications which Eddington's conjecture has for the foundations of physics, it is important to know, regardless of the validity of Eddington's fundamental theory - or other theory - whether the conjecture is true. Is there a simple mathematical expression for these numbers. But apart from the context of a theory can the conjecture have a meaning?

Meaning may be given to the conjecture, without an explicit theory, if two specifications are agreed to. (1) A specification as to degree of fit between the observed value and the mathematical value, and (2) a definition of simple. The form of specification (No. 1) which most physicists would insist on is that the fit be such that the difference between the mathematical and observed values be less than the experimental uncertainty in the observed value. As subsequent experiments improve the observed value, the difference must remain less than the new observational uncertainties. In this sense the mathematical value legitimately plays the role of a hypothesis, i.e., the hypothesis that a purely mathematical expression, M = the value of the dimensionless physical constant. If refined observation shows the observed value does not converge to M, the hypothesis fails to make valid predictions and is discarded. So long as the observed value continues to converge to M, the hypothesis may be used as any conventional hypothesis derived from theory. This is standard procedure.

A satisfactory convention for specification No. (2) is more difficult to formulate. Any numerical quantity can be approximated to any degree of accuracy by sophisticated combinations of basic mathematical quantities. What one considers to be a simple expression is ultimately a matter of personal taste. To avoid these difficulties, we propose as a possible approach to specification No. (2) the introduction of the requirement that the same mathematical expression occurs in at least two of the dimensionless physical constants. By this demand the aspects of simplicity and improbability of occurrence serve as checks on one another; i.e., an expression which begins to reach a level of complexity which exceeds the threshold of permissibility as simple, and therefore appears to be ad hoc, is at the same time reaching a level of improbability of simultaneous occurrence by chance in two or more cases. Hence, involvement in two or more instances restores the expression to continued interest as arising from real, albeit unknown, relationships. The essential feature of meaningfulness - interpretability through theory - is deferred. The existence of sufficiently accurate replication of a phenomenological feature together with a sufficiently large improbability of this being a chance occurrence combine to create confidence in significance and ultimate interpretability by theory. Reasoning such as this has been implicit in the rationale for continuing interest by astronomers and physicists in observed, but inexplicable features, such as the Titius-Bode Law.

In this epistomological context, the following hypothesis "M" is proposed: in the usual notations, three dimensionless physical constants, the Sommerfeld fine structure constant,

$$\alpha = \frac{2\pi e^2}{hc}$$

and the ratio of Coulomb to gravitational forces,

$$S = \frac{e^2}{Gm_p m_e}$$

and the ratio of proton to electron mass,

$$\mu = \frac{m_p}{m_e}$$

are given by the following purely mathematical quantities.

$$\alpha = \frac{1}{2 + \omega} \text{ ; and } S = \frac{2^{\omega}}{2\pi^2} \text{ ; and } \mu = 6\pi^5$$

where $\omega = \pi^4 \ln 4$ (natural logarithm). The mathematical value of α^{-1} to nine significant digits is 137.037664. The present but observed values for α^{-1} are between 137.0352 and 137.0387 with a minimum error adopted value of 137.0378 (Cohen, E. R., NASC, M384, p. 6). For specification No. (1) mean values and "adopted values" are of less interest that the range in recent determinations.

The logarithm to the base 10 of the mathematical value of S is 39.355058, while the present observed value is close to 39.356. A more accurate observed value cannot be given until better determinations of the gravitational coupling constant G have been made.

The mathematical value of $6\pi^5$ = 1836.118101, while the best present observational value of the ratio mp/me is 1836.12.

The quantity $\omega = \pi^4 \ln 4$, appearing in the mathematical values of both α and S thus satisfies specifications No. (1) and No. (2). The occurrence of ω in both numbers reduces the likelihood of its being ad hoc, yet it is still a "simple expression" involving only integers and the basic mathematical constants π and e. The quantity $6\pi^5$ meets even more satisfactorily specifications Nos. (1) and (2). Granting the epistemological rationale of the two specifications, we conclude - until more refined observations contradict the mathematical values - that

Eddington's Conjecture appears to be true.

The exhibiting of a simple mathematical expression whose value lies within the measurement uncertainties of the physical quantities does not constitute a proof of Eddington's Conjecture. However, since present experimental accuracies allow for a test to six significant figures, the sieve for isolating "simple" expressions is becoming fine, and the ability to pass the sieve in three cases certainly is reasonable grounds for the "M" hypothesis.

The question here is, since proof is lacking, and can probably only be given in terms of a physical theory, can the "M" hypothesis be put to any use.

I think the answer is yes. The properties of the mathematical expression can be studied. These may give clues to physical relations but several interesting inferences can be drawn.

CONCLUSIONS

What are the implications of the expressibility of the fundamental dimensionless physical quantities in terms of purely mathematical constants?

First, there is the inference that local conditions are not atypical, i.e., the "universal constants" are really universal. A second consequence of the truth of the conjecture would be that the dimensionless constants, μ, α, and S do not vary with time.

This does not preclude the separate variation of G, h, etc., but requires any variation of fundamental constants with time to be such that

$$\frac{d}{dt}\left(\frac{2\pi e^2}{hc}\right) = 0; \quad \frac{d}{dt}\left(\frac{e^2}{Gm_p m_e}\right) = 0; \text{ and } \frac{d}{dt}\left(\frac{m_p}{m_e}\right) = 0.$$

Third, there is no known theoretical relation between G and the other fundamental constants of physics. Hence, a second interesting consequence of the mathematical formulae is a possible relation linking G and the charge to mass ratio of the electron:

$$G = \frac{8\pi^2}{2^{1/\alpha}} \frac{m_e}{m_p} \left(\frac{e}{m_e}\right)^2 = \frac{4}{3\pi^3 2^{1/\alpha}} \left(\frac{e}{m_e}\right)^2$$

This equation may have interesting implications for relativistic electrons. If mass is velocity dependent and charge is not, then G must also be velocity dependent.

Fourth is the matter of Repitaxis and Metataxis. The basic values discussed above are fundamental to the structure of the atom, but they also occur in higher order aggregates like stars. Since the stars are made of atoms it is likely that they would reflect in their own structure the structure of the atom, just as the macroscopic shape of a crystal replicates the molecular structure of the molecules composing the crystal. We shall call this view - the repitactic view - the large deriving its properties from the small. Or inversely the small deriving its properties from the large - The Machian repitactic view.

The second point of view is that the atom, the star, the galaxy, etc., derive their structural limitations, not from one another, but from underlying structural laws which independently govern all aggregates whatever their scales. This point of view we may name metatactic. Our question then becomes: Is the universe repitactic or metatactic and can we discover the answer in the nature of the cosmic numbers?

If it proves that the dimensionless physical constants indeed are determined by certain geometrical or combinatorial theorems - or even number theoretic relations - accounting for the presence of the basic mathematical constante, π, e, etc., and being independent of physical scale, then the surmise that physical structure derives directly from a more basic non-physical structure leads to a metatactic view of the universe. If π's, e's, etc., appear as the result of properties of quantities with physical dimensionality, then either a reductionist or Machian repitactic view is supported. The present findings are supportive of the metatactic view but this is not surprising for the Einstein Field equation,

$$R_{AB} - \frac{1}{2} R g_{AB} = \kappa T_{AB},$$

have already equated geometry and physics.

The primary importance of the repitactic vis-a-vis metatactic views is in the process of development of our theories. If the substructure implied by metataxis exists, then theoretical attempts to explain the phenomenological world without it, even if successful, may become quite complex. Further a metatactic universe, allows for an explanation of human understanding and a resolution of the subjective vs. objective problem. In a metatactic universe, the substructure maps not only onto the physical world but onto the mental patterns by which the world is understood.

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April 13, 1966

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Some Principles of Hierarchal Structure

A common feature to a large class of structures and organizations, both natural and artificial, is hierarchal form. Whether the hierarchy is that of the cosmic environment: stars, galaxies, clusters of galaxies; or the social environment: neighborhoods, cities, metropolitan areas; there appear to be similar basic principles which define and limit each aggregate and lead to hierarchization. In order to approach the formulation of these principles it is instructive to inter compare the observables and descriptors of several types of hierarchies. Recent developments in astronomy hold some possible clues to the basic parameters which ~~gxxxx~~ govern the sizes and energies of aggregates.

draft: 3.27.66 A.Wilson

Lecture SIU - April 13, 1966

From time to time astronomers, who usually ~~have~~ are facing the stars with their backs turned on the human environment, turn around and point out something interesting that they have observed. They like to share their findings, but they recognize that they are generally regarded as being very much on the fringes of the practical world. However, one time when ~~the~~ astronomers turned around and muttered about their discoveries, they started a chain reaction in the world of practical affairs. The studies of the motions of planets by Tycho and Kepler led to the discovery of the laws of dynamics which led to the development of the science of mechanics, which in turn allowed the development ~~into~~ of scientific engineering, and finally, in the Eighteenth century launched the industrial revolution. This was followed by subsequent technological revolutions which have been sweeping us along ever since.

More recently, an astronomer turned around and muttered something about energy sources in stars and started a chain reaction in the minds of physicists which led to a different sort of chain reaction and started another revolution.

Today, with the advent of the so-called space age, I note with trepidation that astronomers have again turned around and are ~~talking~~ muttering more than ever before - ~~talking~~ in government committees, NASA staff meetings, Air Force planning groups - even discussing structures at SIU. The world has all the revolutions it needs right now. My advice is to get the astronomers back to their telescopes. ~~But~~ whenever ~~if you give them a chance to talk, they will~~.
Since there is a shortage of telescopes - this might be our most effective argument for obtaining additional funding.

SOME PRINCIPLES OF HIERARCHAL STRUCTURE

This evening, I would like to discuss one of the most universal phenomena concerning structure with which we are acquainted - the phonomena of the hierarchal ordering of aggregates. We encounter hierarchal structure ubiquitously in our internal and external environments. It is basic to our thought patterns and to our classification systems. We organize ourselves hierarchically in our social order, in government, in the military, in corporations. We observe the ~~wide-spread~~ existence of hierarchal structure in the biological world. We observe hierarchal structure in inanimate matter. But In spite of the ubiquity of this phenomena, at the present time we have no comprehensive explanations as to why nature, including ~~we~~ man, ~~ourselves~~, organizes in a hierarchal manner.

Perhaps there is no single principle or meta-principle underlying and causing hierarchal organization. There may be as many reasons for it as there are hierarchies. But whenever diverse agencies employ the same technique, there must be something of value in that technique. We may, accordingly, reasonably inquire what common value giving features ~~giving value is it possible to~~ may be abstracted from different hierarchies. Whether hierarchies have a common cause or merely share certain common features is a metaphysical question. Our present concern is not to explore that question, but merely attempt to identify similarities and differences in hierarchies whenever possible. Not initially to seek explanations, but rather, to <u>observe</u> any relationships and patterns in structure that may be evident in ~~the~~ whatever data ~~which~~ is well established and generally available.

This may prove to be a very important quest, especially in our times when the complexities of life are increasing, and available space is decreasing. Every possible economy, every possible bit of guidance, which can be ascertained may be basic to our survival tomorrow. It will pay us to explore whatever organizational principles exist in the universe, be they informational, physical, psychological, social, or whatever.

Before I go any further in a discussion of hierarchal structure, I had best define how I shall be using the term. A hierarchal structure is a structure which consists of a set of aggregates, the elements of each aggregate being themselves aggregates, whose constituent elements are in turn aggregates, etc. This sequence may or may not terminate on either the small scale end, or the large scale end.

Because the study of inanimate matter has proven far simpler than the study of bio-organisms or social organisms, the easiest place to begin is perhaps with material aggregates. It has been recognized for over two centuries that the cosmos might be constructed along hierarchal lines. The first surmise in this connection was purely speculative and was proposed by the Swedish philosopher, Swedenborg. In 1750, the Alsatian physicist, Lambert, hypothesized that the universe was constructed hierarchically. He was impressed with the fact that the newly invented telescopes had revealed satellite systems for the planets Jupiter and Saturn which resembled miniature solar systems. Lambert pursued the analogy between the orbiting satellites around Jupiter and Saturn and the orbiting planets around the sun. He speculated that perhaps the sun, itself, could be a satellite revolving about some distant center in the universe in a planetary-like orbit. (He did not, of course,

~~realize~~ know that the sun ~~indeed~~ moves in a planetary-like orbit about a galactic center thirty thousand light years distant in the direction of the constellation of Sagittarius. All of this was to be discovered later.) Lambert extended his speculations postulating an entire hierarchy where the center about which the sun moved in a planetary orbit itself moved about some even more remote center, etc., etc. Subsequent developments in astronomy have shown that the universe, even though not constructed along the lines imagined by Lambert, was indeed hierarchal.

In 1826 a German physician named Olbers became interested in the question of the extent of the universe of stars. Through a simple calculation he showed that if the universe were composed of stars, like the sun, uniformly distributed, and if there were an infinite ~~in extent~~ number of them, that the brightness of the sky should be as bright as the sun everywhere. But since the sky is dark at night, possibly the universe was not infinite. Olbers preferred to hold to the infinity of the universe and assume there was some other cause for the darkness. He postulated there to be some intervening cosmic dust which cut off the light from distant stars. The urge to preserve the infinitude of the universe led other astronomers to seek causes for what had come to be called Olbers' paradox. Early in this century a Swedish mathematician, C. V. Charlier, proposed a solution in which he showed that if the universe, instead of being composed of an infinite distribution of stars, were hierarchically structured, these stars being grouped into galaxies, and these in turn grouped into super aggregations, etc., that we could have any brightness of the night sky and yet have an infinite number of stars in the universe. Shortly after the work of Charlier, the general theory of relativity was introduced which provided alternative solutions to Olbers' paradox.

Relatavistic models of the universe were based on assumptions of uniform density and hierarchal structure has not so far been used as a base of relatavistic cosmological considerations.

However, The recent establishment of the existence of second order clusters of galaxies by Abell requires that hierarchization be taken into account in all realistic models. ¶ Professor Shapley, the Emeritus Director of the Harvard Observatory, has long been intrigued with the hierarchization of matter and has written two books in which he describes this interesting phenomenon.

1

The first slide summarizes Shapley's classification of the material systems found in the universe. Shapley has assigned an index designating the order or rank of an aggregate in the hierarchy. He gives the fundamental particles composing the atoms an index of -4, the atoms -3. Next come the molecular systems, including crystals and colloidal systems; then meteoritic associations, built up from molecular systems; satellite systems; stars; star clusters; galaxies; clusters of galaxies; the metagalaxy; and the universe: each level being an aggregate or set whose elements are in turn the aggregates of order one less. This classification shows us that in the scale interval of the universe with which we are familiar, the scale-wise structure is definitely hierarchal. We have no reason to assume that the largest aggregate that we now know is the largest which exists (saving the term universe for the last). Although arguments from analogy are often persuasive, arguments based solely on analogy cannot definitively establish whether the hierarchy continues to larger and larger aggregates, and there may be no way to establish whether or not the universe is hierarchal ad infinitum. Shapley's table illustrates the different known aggregates of matter in order of size and mass. It is not proper to assume that all aggregates listed be given equal weight in this hierarchy. Later we shall see that there are basic aggregates which we may call primary and the others must be regarded as satellitic aggregates.

1 off

CLASSIFICATION OF MATERIAL SYSTEMS

(AFTER SHAPLEY)

- -5 Quarks
- -4 Corpuscles (Fundamental Particles)
- -3 Atoms
- -2 Molecules
- -1 Molecular Systems
- +1 Meteoritic Associations
- +2 Satellitic Systems
- +3 Stars and Star Families
- +4 Stellar Clusters
- +5 Galaxies
- +6 Galaxy Aggregations
- +7 The Metagalaxy
- +8 The Universe: Space-Time Complex
- +9 ....

Four basic questions arise. First, why is matter organized in a hierarchal manner. Second, why do the particular aggregates having the masses and sizes which they have occur in nature and why not other aggregates with different masses and radii. Or, specifically, why does a star or a galaxy have the mass and radius it has? Third, since we do not encounter other bodies in unlimited assortments, we may ask do other bodies exist, but have escaped observation, or is the hierarchal structure truly discrete and completely represented by known aggregates. And the fourth question, how far does the hierarchal structure extend both down in scale and up in scale. Is it open ended or does it terminate.

In looking at the cosmic portion of total interval of observable levels in the hierarchy, we find two advantages. First, there exists a descriptor which may serve as the basis for comparisons which may be readily deduced for all aggregates in the hierarchy from simple accurate observations; and second, we have approximate spherical symmetry in all aggregates. The relations may be expected to be simpler and depend on fewer parameters in the case of the cosmic aggregates than in the case of terrestrial aggregates.

The basic descriptor available to us for comparisons of cosmic bodies is the simple ratio of the mass (M) to the radius (R) of the aggregate. Its evaluation depends in each case on Kepler's Third Law, but in each case on an independent technique. Kepler's Third Law is one of the most powerful tools available to the astronomer.

$$P^2 = \frac{4\pi^2 a^3}{G(M_1+M_2)} \qquad \text{or} \qquad \frac{G(M_1+M_2)}{v_0^2\, a} = 1$$

This law, first discovered by Kepler, and later modified by Newton, allows the astronomer to measure the masses of interacting heavenly bodies provided he knows their distances of separation and either their velocities or periods of rotation about one another. Usually, if we are to determine some explicit property of a celestial body such as the mass or the linear size, we have to know the distance to the body. But a useful thing about the ratio of mass divided by radius, it may be determined without having to know the distance to the object under study. This is a tremendous advantage because of the difficulties and uncertainties in determining distances to celestial bodies, especially the more remote ones whose distances can only be determined through iterated calibrations and compounding of several methods of distance determination. The observations required for determination of M/R are straight forward being mostly observations of ~~spectral~~ radial velocities, angular dimensions, and light variations. The observations of radial velocities which are determined from the doppler shift of spectral lines can be made with as high precision as any observations in astronomy.

The ratio of mass to the linear radius is determined in different ways using different techniques for each of the four aggregates which are available to observation. For stars the ratio of the mass to the radius may be determined in the case of a type of star known as an eclipsing variable or eclipsing binary. These are a pair of stars orbiting about one another in a plane which happens to pass through the earth. In this case, we see the stars eclipsing one another. Aside from the sun our knowledge of accurate masses and radii of stars are limited to those of eclipsing binary stars. I will not go into the details of the determination, other than to say it is an observation involving the period, light curve and the spectral orbit of the stars. ~~Now~~ For galaxies, $\frac{M}{R}$ may be derived in at least two ways and with less certainty, in a third way. ~~A~~ One basic way of determining the ratio of the mass to the radius ~~are~~ is to observe the spectra of the rotating galaxy placing the slit along the equator and measuring the inclination of the spectral lines. This angle of inclination together with the angular radius and the linear value of the Doppler velocity, allow us to determine the ratio of $\frac{M}{R}$. Again, no knowledge of the distance is required. ¶ To determine the $\frac{M}{R}$ ratio for a cluster of galaxies we employ what is known in mechanics as the virial theorem which gives the value of $\frac{GM}{R}$ in terms of the dispersion of the velocities of the members of the cluster. Since velocities can be determined from the redshifts which are directly observable, it is possible without any assumptions whatsoever concerning the distance to the cluster, to evaluate the $\frac{M}{R}$ for the cluster directly. In the case of the second order clusters the same technique can be used but also the mass and radius can be extrapolated from counts of the number of clusters in the second order cluster, from masses of clusters, and observed angular dimensions converted to linear dimensions by redshifts. The extrapolation method, however, is not independent.

We thus have three independent types of astronomical observations for the three species of aggregates, stars, galaxies, and clusters which allow us to determine the ratio of $\frac{M}{R}$ for each species directly from observation. I wish to emphasize again that the methods, ~~though all based on Kepler's law,~~ are independent, are based on different observables, and involve essentially no theoretical assumptions beyond Kepler's Law.

When one compares the values of the mass to radius ratio for the different aggregates, a very interesting coincidence is observed. On the basis of the sample of all available eclipsing binaries (and the sun) we find that the maximum value assumed by the ratio $\frac{M}{R}$ in metric units of grams per centimeter is $10^{23.3}$. For the available sample of galaxies whose mass to radius ratio has been determined, we find that the maximum value which occurs is $10^{23.6}$ grams per centimeter. The mass to radius ratio determined by the virial theorem for all of the clusters of galaxies for which sufficient data is available again gives $\frac{M}{R}$ equal to $10^{23.5}$. The super clusters of galaxies can be studied by taking the values for clusters of galaxies and multiplying by the number of clusters in the super cluster and using the proper mass for a cluster and the observed radius for the super cluster. Again we come up with $10^{23.2}$ for the $\frac{M}{R}$ ratio.

We thus find the rather startling result that the maximum ratio of mass to radius for every species of non-degenerate cosmic aggregate that we know has the same value in grams per centimeter, namely, $10^{23.5}$.

The fact that this ratio is bounded is not completely unexpected. The German astronomer Schwarzschild in 1916 obtained an exact solution of the Einstein field equations of general relativity under certain assumptions, including spherical symmetry. The Schwarzschild solution led to the three famous predictions of the general theory of relativity. These predictions consisted of 1) the advance in the perihelion of the planet Mercury, that is the prediction that the major axis of the planet's orbit rotates in space in a manner different from that predicted by classical Newtonian theory. The second prediction was that a ray of light passing near a massive body, like the sun, would be deflected. This may be tested by making observations of the star field surrounding the sun during a total eclipse and comparing the same star field photographed in the night sky six months later. The third prediction was the so-called Einstein or gravitational redshift. The frequency with which an atom radiates is different when in a strong gravitational field than when in a weak field so that a spectral line coming from an atom on the sun would be shifted in frequency with respect to one originating in a laboratory on the earth. These three effects have been observed. But in addition to these three classical predictions of general relativity the Schwarzschild exact solution makes a fourth prediction. This is the prediction that the quantity

$$\frac{GM}{c^2R} < \frac{1}{2}$$

Here we have multiplied the ratio of M/R by two universal constants: G, the universal gravitational coupling constant, and c, the velocity of light. The resulting product is dimensionless. {energy ratios $\frac{GM^2}{R} / c^2 M$ or $\frac{\text{grav. rad}}{\text{lumin rad}}$

There are several ways of interpreting the Schwarzschild limit. Without going through the details of the derivation, we may see that the limit is an immediate consequence of classical Newtonian theory and the relativistic assumption that there exists a limiting velocity for material objects, namely the velocity of light. Classical Newtonian mechanics leads to a formula

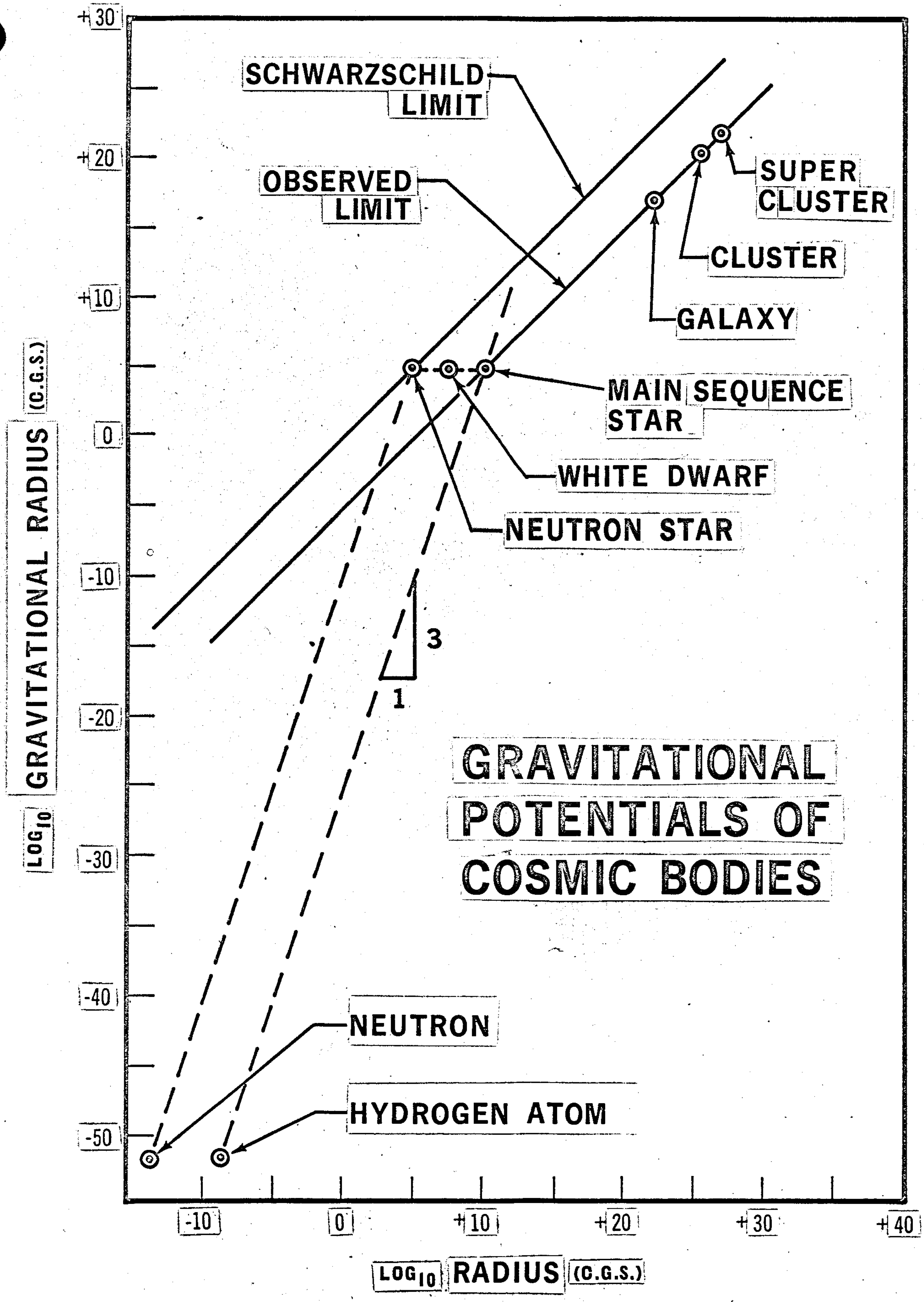
$$\sqrt{\frac{2GM}{R}} = V_x$$

where V_x equals the velocity of escape. In the case of the earth, substituting the mass of the earth and the radius of the earth in this equation we find the velocity of escape is about 11 kilometers per second. For the sun the value is about 620 kilometers per second. For the Moon it is in the neighborhood of 2 kilometers per second. What the Schwarzschild limit implies is that no aggregate in the universe can assume values of $\frac{M}{R}$ which make the velocity of escape greater than the velocity of light. Another way of looking at the escape velocity is, if a particle is released at a very large distance from a body and allowed to fall freely it will accelerate until the speed with which the falling body strikes the surface of the planet is equal to the escape velocity. Consequently the Schwarzschild limit states that any body which is accelerated only by gravity has a limiting velocity of c.

Recapitulating, we have from the general theory of relativity that the ratio of $\frac{M}{R}$ is bounded and the dimensionless quantity $\frac{GM}{c^2R}$ has the bound of one-half. Observations show that $\frac{M}{R}$ is indeed bounded but that the quantity $\frac{GM}{c^2R}$ for the all observed nondegenerate systems has the bound, not of one-half, but of a quantity which has the value of about $10^{-4.3}$ (from $\frac{G}{c^2} \times 10^{+23.5}$). Why this discrepancy? It is here that the matter of degeneracy comes in. If we assume a model in which hydrogen atoms are spheres whose radii are of the order of 10^{-8} centimeters and if these spheres are packed solidly as one would pack cannon balls or marbles, a large aggregate of hydrogen molecules can be assembled. The question is, assuming an aggregating principle-like gravity which assembles atoms until a large mass has been built

$\boxed{2}$ up, how big may the mass be? The slide shows us what will happen. Across the bottom of the slide is plotted the logarithm of the [80x50 cycle log-log plot] radius of the aggregate, cosmic or atomic, in centimeters; vertically is plotted the quantity $\frac{GM}{c^2}$ which is called the <u>gravitational</u> <u>radius</u>. Multiplying the mass by the fundamental constants $\frac{G}{c^2}$ converts the dimension mass into the dimension length hence the name mass radius or gravitational radius. We are thus able to compare masses and lengths and the ratio GM/c^2R becomes dimensionless. The mass of close packed hydrogen atoms under consideration would grow up along the dotted line passing through the hydrogen atom and having a slope of 3 to 1. This is a line of constant density. Growth could continue until encounter with the Schwarzschild limit. Growth is not possible beyond that. No physical body can be any larger than that determined by this limit. However, if it is the second or $10^{-4.3}$ observed limit which really governs any aggregate of closely packed

2



GRAVITATIONAL POTENTIALS OF COSMIC BODIES hydrogen atoms, then the mass could become no larger than determined by the intersection of the constant density hydrogen line with th~~e~~s observed limit. It is precisely at this intersection that we observe the aggregate we call stars. The mass determined by the intersection of the two lines has a value of 10^{33} to 10^{34} grams. This is the observed mass for ordinary stars. Hence, we have here a partial answer to one of our three basic questions, why stars have the masses which they are observed to have. Alternatively, observed stellar mass may derive from the intersection of a constant density line for close-packed nuclear particles with the Schwarzschild limit. If instead of taking hydrogen atoms we take neutrons or nuclei of hydrogen atoms and pack them closely we find the same cutoff mass, 10^{34} grams, from closely packed neutrons being cutoff at the Schwarzschild limit. This notion follows conditions hypothesized for the initial state of an expanding or "big bang" cosmology. Thus there exists a parallel between atomic size with the observed limit for non-degenerate cosmic aggregates ~~in the universe~~ and neutron size with the theoretical relatavistic Schwarzschild limit. In fact the $10^{-4.3}$ bound is very closely equal to the ratio of the size of the nucleus to the first Bohr radius of the atom. We are here apparently encountering a manifestation of atomic ~~dimensions and~~ ratios on a cosmic scale.

The use of close packed models, though quantitatively consistent for the features we are discussing, is not a correct model for a star. We have ignored the thermal energies which are of the same order of magnitude as the gravitational energies. But to move a stellar point down by 0.30 (log 2) on our log-log diagram is to move it through the diameter of the dot representing the star. So for our present discussion we may ignore the details of stellar structure and consider a star to be a close-packed aggregate of hydrogen atoms.

~~TAPE #4~~

This is a rather exciting parallel. For several decades cosmologists have suspected that there exist~~s a~~ relationships between the properties of structures ~~which are observed~~ on the cosmic scale and the basic properties of the atom, which is the fundamental building block of all larger aggregates. Over thirty years ago, ~~In the twenties~~, Eddington pointed out the identity between basic dimensionless numbers associated with the properties of the atom~~s~~, and basic dimensionless numbers associated with the cosmos. For example, $e^2/Gm_pm_e = 10^{39}$ and $cH/r_e = 10^{39}$ where $r_e = e^2/m_ec^2$ is the radius of the electron. These numerical identities have been regarded by many physicists as merely coincidences. Yet, when dealing with numbers of the order of magnitude of 10^{+39}, it is a little difficult to account for two such numbers coming from two spins of a wheel of chance - unless there are only a very few numbers on the wheel and that would be an even more remarkable situation. But now we have further evidence in slide 3 ~~substantial sort~~ for the existence of basic relationships between atomic and cosmic structure. Another of the dimensionless numbers considered by Eddington is the Sommerfeld-Fine structure constant (α) which was first discovered in atomic spectra. (The reciprocal of this number has a value of about 137.) The ratio of the size of the first Bohr orbit in the hydrogen atom to the electron radius is equal to the square of this number = $10^{+4.27}$ and it is quite possible that this is the reciprocal ~~same number~~ of our $10^{-4.3}$. If so, we may write $GM/c^2R \leq \alpha^2$.

Now let us return to the concept of degeneracy. Whenever the spheres of hydrogen atoms become more closely packed than their unperturbed radii permit or whenever the electrons present do not have a suitable number of states to occupy, a condition of matter which we call degeneracy arises. It is like having to stack cannon balls together in a space which is so small that the cannon balls would have to intersect each other in order to be squeezed into the space. This, or course, creates very high densities of matter, much larger than any occurring in normal solid state. We actually do observe bodies in the universe which ~~do~~ have these high densities and manifest the property of degeneracy. These are stars which are known as white dwarf stars. They are located on the diagram between normal stars and neutron stars. They have values of $\frac{M}{R}$ which are greater than the values observed for the nondegenerate aggregates, the main sequence stars, galaxies, etc., but less than the Schwarzschild limit. We are led to ~~conclude~~ surmise that the smaller $10^{-4.3}$ limit applies to nondegenerate aggregates of matter, while the Schwarzschild limit applies to degenerate aggregates and is the ultimate limit. In other words, if one regards ~~the~~ neutrons as the ultimate cannon balls, they cannot be packed more closely than their radii allow, nor in ~~masses~~ aggregates greater than the Schwarzschild limit will allow. ~~We thus have the limiting properties of space are related to the properties of matter through the density and energy limits shown on the diagram.~~ Furthermore, whereas the Schwarzschild limit corresponds to the velocity of light, the $10^{-4.3}$ observed limit corresponds to a velocity which is equal to the velocity of light divided by the Eddington number, 137. This has a value of around 2,200 kilometers per second. Hence the maximum escape velocity from any nondegenerate star, galaxy, cluster or super cluster, is the same and equals about 2,200 kilometers per second. This is the fastest that one would expect to find any material body in the universe being accelerated by the ~~gravity~~ gravitational field of a non-degenerate body. It is interesting to note that the circular velocity corresponding to this value of αc is exactly the velocity with which an electron moves in the first Bohr orbit. Another parallel between the atomic and cosmic structure.

On the basis of the limits shown in the diagram can we get any clues toward ~~an~~ some answer to the question why hierarchization occurs. ~~Considering further, the answer is, yes.~~

3

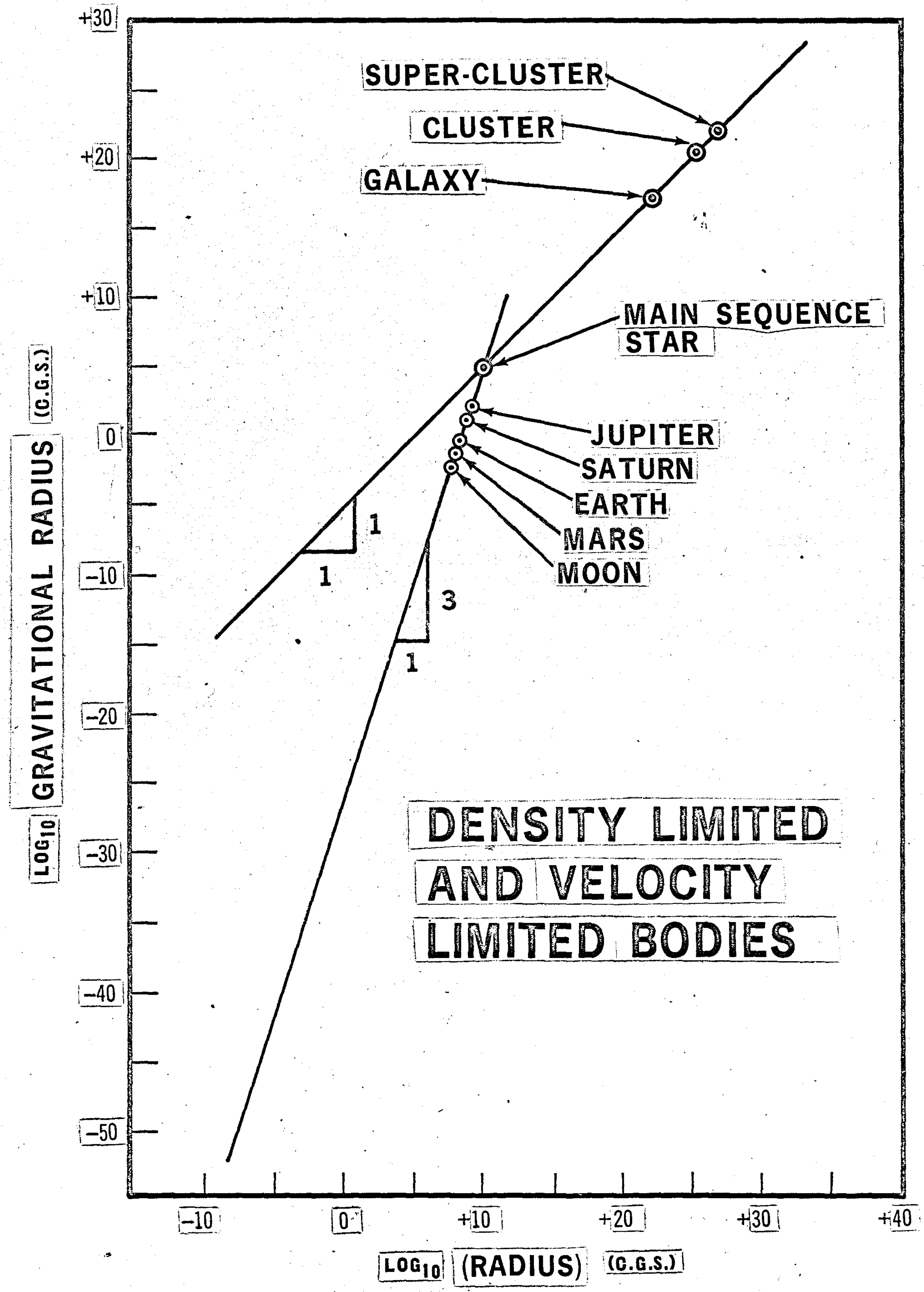
The third slide has the same axes as the second. The 1:1 slope line is the observed limit for all nondegenerate bodies and the 3:1 slope line is the observed distribution for non-degenerate solid bodies with densities the order of hydrogen atom density. These solid bodies, the planets, Jupiter, Saturn, etc., do not all have the same density, but on the scale of this diagram they are approximately the same. The densities range from about one to six. ~~Hence, these bodies~~ and are all on essentially the same constant density line. We see that there are two types of limiting aggregates in the universe: those falling along the constant density line - planets and stars - these are density limited and are interpretable on a model of atoms close packed in volume. The second type of body, those which lie along the observed $10^{-4.3}$ limit with the slope one to one, are velocity limited. We have seen that the escape velocity for all of these objects is identical and of the order of 2000 kilometers per second. In the velocity limited bodies there is freedom of motion among the elements of the aggregate. On the other hand there is essentially no motion in the lithospheres of planets, and only fluid motion in the atmospheres. We can accordingly think of these two classes of bodies as (1) static bodies - those which are density limited, and (2) dynamic aggregates - those which are velocity limited.

$\frac{M_*}{R_*} = \frac{M_G}{R_G} = \frac{N M_*}{R_G}$

$R_G = N R_*$

There is yet another relationship governing the velocity limited bodies. That is this. Since M divided by R is the same for all these bodies and the mass of, say, a galaxy is equal to the mass of a star times the number of stars in the galaxy, it follows that the radius of a galaxy is equal to the number of stars in the galaxy times the radius of the star. The same is true for clusters, etc. In other words, instead of being close packed in volume, the objects which lie along the velocity limit line are <u>linearly close packed.</u> The diameter of any aggregate is equal to the diameter of the element composing that aggregate, times

3


SUPER-CLUSTER
CLUSTER
GALAXY
MAIN SEQUENCE STAR
JUPITER
SATURN
EARTH
MARS
MOON
1
1
3
1
DENSITY LIMITED
AND VELOCITY
LIMITED BODIES
+30
+20
+10
0
−10
−20
−30
−40
−50
−10
0
+10
+20
+30
+40
LOG10 GRAVITATIONAL RADIUS (C.G.S.)
LOG10 (RADIUS) (C.G.S.)

the number of elements in the aggregate. We thus have two types of packing - the velocity limited bodies are linearly packed, or 1-packed even though they are three dimensional bodies and occupy three dimensional space, the diameter assumed is just the linear extension of the particles making up the body. The solid bodies may be made by volume-close-packing of elemental spheres, or 3-pack either hydrogen atoms for nondegenerate, or neutrons for degenerate objects.

Several aggregates are known to exist which lie below the $10^{-4.3}$ observed limit for velocity limited bodies. These bodies are <u>less</u> than linearly packed. That is, the diameter of the aggregate exceeds the linear extension of the constituent particles. It thus appears that in nature dynamic aggregates are never pressed into a volume any smaller than one whose diameter is defined by linear packing. This observation may be of extreme importance in the design of all dynamic systems required to be collision free, which is essentially true of cosmic aggregates.

In slide 3, we can represent gravity by a vector force field which causes all bodies in the lower right part of the diagram to contract, i.e., to move to the left; and, possibly to grow in mass accretively, i.e., to move upward. Motion will continue until one or the other limits - the density limit or the velocity limit is reached.

If the density limit is reached, the object may continue to grow in mass under gravitation, but will also have to increase in size. Mass and size may increase until the velocity limit is reached. Here in the corner made by the intersection of the two limits, we encounter a stable position. This corner is occupied by the stars.

Further growth along the density limit is impossible. To build a larger aggregate growth must ~~continue~~ proceed along the velocity limit. The aggregating force of gravity here effects a growth in linear size proportional to the growth in mass. This means that each addition of a unit of mass demands an <u>increase in volume proportional to the square of the number of particles already present</u>. Any cosmic body <u>accreting</u> along the velocity limit will therefore have to <u>expand</u>.

Omit

Growth along the velocity limit in effect amounts to an adjustment of the body to a density distribution which is such that the density at distance r from the center is proportional to r^{-2}. A body which may be stable under maximum constant density, when reaching this limit must expand and adjust to a r^{-2} density distribution.

Growth may not proceed smoothly up the velocity limit. Expansions will take bodies to the right of the limit. Such bodies, considered now as elemental particles, may accrete along a constant density line until the velocity limit is again reached. This process may be repeated. We can qualitatively account for hierarchization by speculating that this is how the two limits interact with gravity and build up higher order aggregates. The argument is quantitatively consistent as far as stars are concerned. Beyond the stars there remain many uncertainties. and There is no clue as to what positions, if any, are stable.

A non-accreting body on the velocity limit, will ~~&~~ under gravitational forces tend to contract. But in order to contract, it must lose mass. If mass is expelled, in effect the size of the aggregate increases. An object placed under such conflicting demands will develop schizophrenia. It will explode. Stellar explosions of various types are frequently observed. These may be due to attempts to adjust to the velocity limit. The core drops below the line, the exploded shell moves to the right. Further contraction may ensue and the process repeated until a point of stability is reached. [3 off]

All of this suggests a general theorem underlying hierarchal structure.

1. If there exists an aggregating principle (such as gravity).
2. If there exists a maximum limiting density (slope 3).
3. If there exists a velocity (or energy) bound (e.g. $\frac{\frac{GM^2}{R}}{C^2M}$), (with slope < 3).

then, Matter will be (a) hierarchically structured, or (b) adjusting itself so as to be distributed in accord with the density distribution demanded by the energy bound. ~~which in general requires expansion~~.

Before this theorem can be completed, something further about stable positions along the velocity limit must be determined.

Recapitulating, In studying cosmic aggregates we have identified two types of limits which govern cosmic structure; a density limit, and a velocity limit. Where these two limits intersect a very basic and universal event occurs, namely the stars. We have further seen that the existence of these limits, together with an aggregating principle such as the law of gravity, can lead to hierarchic structure. We have not, however, been able to show why aggregates other than the basic aggregate of the star occur in nature. It seems as though some supplementary relationship such as a ~~universal cellerization~~ "cell - nucleus" property for ~~of~~ all aggregates needs to be postulated before we can reconstruct completely the observed hierarchal distributions.

Let us now turn from cosmic aggregates of the one-pack and three-pack varieties, keeping in mind what we have ~~learned~~ found, and consider ~~other~~ another type~~s~~ of aggregate~~s~~ ~~and~~ composed of a different type of element. ~~hierarchies.~~ Let us consider, ~~for example,~~ a typical human social organizations, ~~such as~~ the city. (Which has recently based its activities about the six-pack) Is it possible to detect anything in the structure and the behavior of humans and of the city which is similar to the two limits detected in the cosmos? We are certainly aware of one limit - the limit of maximum density. Human beings cannot live together in too compact a state. There is a certain minimum number of square feet required for life to be possible, even in a concentration camp or prison. ~~Precisely what~~ The precise value of ~~this basic~~ the minimum area required to sustain human life ~~is~~ may be hard to ~~isolate~~ measure, ~~and~~ It ~~may~~ probably depends upon several factors. and is different for different cultures and levels of technology.

But we can assume that parallel to the density limit which exists for inanimate particles, there does exist a maximum density limit applying to human beings.

Are we able to detect any limit which parallels the velocity limit in the cosmic structure? The answer here is yes. There is definitely such a limit governing urban structure and this is the limit of the maximum acceptable commuting time. Finally, analogous to the aggregating principle which is at work in the cosmos, namely gravitation, there exists an aggregating principle among human beings. This is their natural gregariousness, their inclination to come together, for physical security, economic security, or emotional security. Since we have for a human aggregation like the city the three essential ingredients of the two types of limits and the aggregating principle, we might expect that an inequality similar to the ones discovered for cosmic aggregates may also exist.

> Let $\hat{\sigma}$ be the maximum possible density, and $\hat{T}$ be the maximum acceptable commuting time.
>
> A characteristic limiting velocity analogous to c exists within a city, call this v_c. This depends on the state of the art.
>
> $v_c\hat{T}$ defines a maximum length $\hat{R}$. The radius of the city R_c, must be less than $\hat{R}$.
>
> N, the population of the city, $= \pi R_c^2 \bar{\sigma}_c$, where $\bar{\sigma}_c$ is the <u>mean</u> density. Since $R_c < \hat{R}$ and $\bar{\sigma}_c < \hat{\sigma}$, we have
>
> $$N = \pi R_c^2 \bar{\sigma}_c < \pi \hat{R}^2 \hat{\sigma} = \pi v_c^2 \hat{T}^2 \hat{\sigma}$$
>
> Hence $\frac{N}{v_c^2} < \pi \hat{T}^2 \hat{\sigma}$ a bound, since the right member is bounded.

We thus see from these equations that there is a marked similarity between a human aggregation which is necessarily dynamic, and dynamic cosmic aggregations. Except for the fact that the city is two dimensional and the cosmic bodies are three dimensional, the equations are parallel in every sense.

If $M_c = N\overline{H}$, a height to make the city three dimensional, and $\hat{\rho}$ = volume density

$$\frac{M_c}{v_c^2 \overline{H}} < B = \pi \hat{\rho}\, \hat{T}^2, \quad [\hat{\rho}\, T^2] = [\frac{M}{L^3}\, T^2]$$

compared with

$$\frac{M}{c^2 R} < B = \alpha^2/G, \quad [\alpha^2/G] = \left[\frac{MT^2}{L^3}\right]$$

Thus $\frac{1}{\hat{\rho}\hat{T}^2}$ is analogous to the gravitational coupling constant.

Finally, it is reasonable to conclude that because of the existence of the aggregating principle which operates in human affairs, and the existence of a density bound, and a velocity bound, that ~~some event~~ and equations similar to those governing cosmic aggregates are likely to occur. I think we may ~~safely reason~~ usefully explore further other parallels by analogy, and say that ~~the event which occurs at the intersection of the density and velocity bounds are the cities.~~ the parallels which exist in these aggregates may give clues which will allow us to further understand ~~both~~ all of them.

Rec'd June 1967
UCLA

COSMOLOGY - THE ULTIMATE ENVIRONMENT

Part I. INTRODUCTION

One of the realizations which has emerged from the scientific age which contradicts a traditional common sense point of view is that entities which are very small or very far away, have little or no relevance for events which occur on the human scale, a scale which we might term the mezzocosmic. We have learned, through the studies of molecules, atoms, nucleii, that the properties of the microcosmos governed to a very large extent through either deterministic or stochastic processes, what happens in the mezzocosmos. In fact, the explosion of the first atomic bomb forever dispelled the prejudice over the irrelevance of the minute. However, it is less evident to us in what way, if any, the macrocosmos, that is, the astronomical environment, governs the mezzocosmos. This is because it is customary to seek the explanation of things by examining their component parts rather than examining the milieu in which they are embedded. To find out what makes a watch tick, we take it apart, we see what the parts are and how they fit together. Our thinking about causality has thus been very much tainted by two centuries of living with machines. The explanation of how a rifle, or an automobile engine, or a TV set works, is to be found inside the rifle, the engine, or the set. The properties of the large may be derived from the properties of the small. The whole is determined by the parts. Causality flows from the micro to the macro. These ideas are so called reductionist point of view. This point of view has formed such a bias to our thinking that we become uncomfortable with a notion that the events on earth may be deterministically or stochastically defined by what is outside the earth. This idea conjures in our minds images of astrology and supernaturalism. We feel it is an absurdity to ask whether the cause of the solar cycle, for example, may not be found outside rather than inside the sun. The fact that physics has been highly successful relying almost exclusively on a reductionist approach is one of our main reasons for repudiating the other approach, the so called wholistic one, which states that the properties of the parts are determined or at least are affected by the nature of the whole, or that the structure of the small derives from the structure of the large. In spite of our successes with reductionism, wholistic effects that need not in any way be considered supernatural or teleological, are demanding attention in many fields of science today. In meteorology no one anymore tries to explain the properties of the atmosphere solely by the reductionist method, looking at properties of small samples of air, or the properties of the molecules out of which air is composed. It is very essential to consider what is going on outside the atmosphere, to consider the milieu in which the atmosphere is to be located, the radiative and particle environments, the rotation of the earth, etc. The biologist has long been concerned with wholistic effects. The structure of the neural optical system of a rabbit which alerts to moving vertical patterns and not to horizontal patterns, is derived from the form and habits of the rabbit's predatory enemies, not from some micro structure within the rabbit's eye. Evidence for wholistic effects in some specifics as in these meteorological and biological examples, creates a climate of permissivity, if not acceptability, to the concept that the properties of bodies which occur at various cosmic levels from the micro to the macro result from an interaction of reductionistic and wholistic sequences of properties. Specifically, a principle might be enunciated which states that the nature of the atom itself in some way is determined by the nature of the universe as a whole. This in addition to that the properties of the universe must be those which derive and are consistent with the properties of the atom. The fundamental constants of physics, Planck's constant, the gravitational coupling constant, the velocity of light, and the fine structure constant, etc., may in some way depend on the total mass of matter in the universe, its rate of expansion, its mean density, etc. This possibility is consistent with the surprising numerical coincidences which exist between the dimensionless micro and macro constants.

This discussion of reductionism and wholism provides a modern rationale for a very important 19th century concept, which has cast its shadow importantly over all the modern cosmology. This is Mach's principle. The above statements concerning the atom and the universe are but generalizations of Mach's principle. This famous principle first arose out of the perplexity over what coordinate frame should be taken as an inertial frame and why. You recall the usual illustration of this question, Newton's rotating pail of water, which assumes a parabolic surface when rotating differentially with respect to the earth. More generally, we might state if two bodies, such as two stars, are rotating differentially about an axis which passes through their two centers, and one star assumes an ellipsoidal form whereas the other remains spherical, the mean positions of the atoms in the spherical star define the inertial coordinate frame. Mach's solution to this paradoxical situation was to state that an inertial frame is determined by the distribution and state of all the matter in the universe. Certainly an example of wholism, if it is true. And in some modified form, this principle does appear to be true.

We cannot at the present time trace in detail causal relations from the macrocosm to the mezzocosm or to the microcosm, but there is evidence, for example, the numerical coindences and the Mach's principle, which suggest that we should be open to cosmological and cosmogonic hypotheses which permit the wholistic direction for causality. We must be open to the idea that what underlies the laws of laboratory physics may be understandable only in terms of the macrocosmos. We shall return to this idea later in connection with some properties of cosmic hierarchies.

II. THE COSMOLOGICAL QUESTIONS

In viewing cosmological questions, we find a curious dichotomy. One set of questions may be termed philosophical, or even theological. These are large general questions, such as, what is the nature of the universe. How did it originate? What is its destiny? And what is the place of life in the universe? What is man's relationship to the universe? These are essential, timeless, cosmological questions. They are found in the cultures of all peoples. They do not arise from the scientific dialectical process of forming hypotheses from observations and testing the hypotheses against additional observations and forming new questions. These basic questions seem to arise directly from the psyche of man. In contradistinction to these large cosmological questions, we find the specific questions which each age casts in terms of its own understanding and which derive from questions posed through its own research and which are meaningful in terms of its own constructs. For example, in our times specific cosmological questions take form such as, is the universe of galaxies best described by a finite or an infinite space. Is the universe in a steady state or is it in an evolving state? Whereas the basic cosmological problem is still centered on the general problem of the origin and nature of the universe, in our times it has several more specific formulations. One very important aspect of modern cosmological research deals with the construction of cosmological models and the comparison of these models with the observable sample of the universe. Instead of trying to build a map of the universe on the basis of observation alone, we find because the number of quantities which we can observe is limited, it is very important to supplement our observations with a theoretical construct. This even more so in cosmology than in other branches of science. The idea of constructing as many conceivable theoretical models as possible and then comparing all of them with the observed world and eliminating those which are inconsistent derives from a philosophical notion of Alfred North Whitehead, the same notion which was applied in mathematics by David Hilbert. This is the system which is employed in modern cosmology.

Modern models are mostly based on the general theory of relativity. This is because it is currently felt that the force which governs the interactions, the motions, the form of cosmic bodies, is gravity and that any model must be built on the best theory of gravity which we have available. This is the general theory of relativity. True, there are models built on other bases, but most current models make use of the gravitational concepts involved in the general theory of relativity. The main stream of cosmological model building has been centered around the so called homogeneous cosmological model in which the matter which exists in the universe is approximated by a uniform perfect fluid whose properties are homogeneous and isotropic. When these assumptions are adopted, Einstein's general field equations

$$(1) \quad R_{ab} + g_{ab}\left(\lambda - \tfrac{1}{2} R\right) = -\kappa T_{ab} \qquad (\kappa = 8\pi G/c^4)$$

with the metric, g_{ab}, given by

$$(2) \quad \begin{cases} ds^2 = c^2 dt^2 - R(t)^2 du^2 \\ du^2 = (dr^2 + r^2 d\theta^2 + r^2 \sin^2\theta \, d\varphi^2)/(1 + kr^2/4)^2 \end{cases}$$

take the form

$$(3) \quad \begin{cases} \lambda + \kappa\rho c^2 = 3(k + \dot{R}^2/c^2)/R^2 \\ \lambda - \kappa p = 2\ddot{R}/Rc^2 + (k + \dot{R}^2/c^2)/R^2 \end{cases}$$

in which ~~the second~~ equation (2) represents the so called Robertson Walker line element.

The problem of model building and selection is to solve these equations with boundary conditions that fit the observed sample of the universe. Our cosmological model according to these equations will be characterized by several parameters. The parameter k represents the constant curvature of the space. In this form k may be equal to either -1, 0, or +1, which represents a space of negative curvature which is an open or hyperbolic space; a flat euclidean space, or a closed positive curvature space which may be either elliptical or spherical. Other parameters or independent variables which appear in these equations are the density ρ and the pressure p. Finally there is a parameter λ, the so called cosmological constant. Many large classes of models assume that this cosmological constant vanishes. It is important to say a word about the history of this constant. It was introduced originally by Einstein because his first solution of equations when he was looking for a static universe was unstable without the introduction of a positive constant. Subsequently, with the discovery of an expanding universe, it was no longer necessary to have this constant. However, it has been reintroduced even though it was removed by Einstein and it is now felt to represent possibly a residual repulsive force whose cause may not be associated with what we normally think of as pressure, although it acts like a pressure. The dependent parameter, R(t), represents the radius of the universe. Our principle problem is to decide how this radius varies as a function of time in accordance with the values at certain times, usually the present time, for the various observable parameters. Two derived parameters are found to be very convenient in characterizing cosmological models. These are H, the so called Hubble parameter, which is equal to our $\frac{\dot{R}}{R}$, and q, the deceleration parameter, which is equal to

$$-\frac{R\ddot{R}}{\dot{R}^2}$$

Thus, in our family of models which are of current interest, there are six characterizing parameters: λ and k are constant, p, ρ, H, and q vary with time. It is the problem of the observational astronomer to determine the present values of p, λ, H, and q in order to decide what ρ and k may be and to describe the functional relationship between R and t.

The slides show the various forms which the equation provides for the function R(t) in terms of the various characterizing parameters.

How are the parameters H, q, ρ, which can be related to observables, to be determined? There are three classic tests due to Hubble and Tollman in which the values of these parameters may be related to various models by means of comparing the counts of galaxies, the diameters of galaxies, or the apparent magnitude of galaxies with the observed redshifts of these galaxies. In essence, these tests show how the observable quantities of the numbers, sizes, and brightnesses change with the distance. Sets of theoretical curves such as those shown in the next three slides can be used for comparison with the observed relationships to decide what model best fits the observed sample of the universe. Because of observational difficulties tests based on counts of galaxies and tests based on diameters have not been found to be very useful. The principal test upon which astronomers hope to determine which model best fits the observed sample of the universe is the magnitude log redshift relationship shown in the third slide. A large class of models with $\lambda = 0$, called Friedman models, have been used by Sandage to approximate the observed sample of the universe. The next slide shows the family of curves corresponding to various values of q in a Friedman model, together with the points representing the redshifts magnitudes of galaxies and clusters.

It is seen that there are two basic parameters which characterize relativistic cosmological models. These are the curvature and cosmological constants. If the curvature takes on the value +1, the universe is said to be closed. If it assumes the value 0 or -1, it is said to be open. The slide shows that open universes will oscillate whenever the cosmological constant is less than 0, they will expand in a decelerating manner if the cosmological constant is equal to 0, whereas they will expand in an accelerated manner if the cosmological constant is greater than 0. These are the only possibilities permitted for open universes. The cases for closed universes, however, are more complex. Again if the cosmological constant is less than 0, the universe will oscillate. If it is equal to 0, it will also oscillate. However, if the cosmological constant is positive, several interesting subcases occur. There exists a critical value of the cosmological constant, λ_c, since the dimensions of the cosmological constant are l^{-2}, $\lambda^{-1/2}$ as the dimensions of length, the critical value of λ corresponds to the gravitational radius of the universe $\frac{GM}{c^2}$. If the value of the cosmological constant is less than this critical corresponding to the gravitational radius of the universe, then the universe contracts then expands according to curve No. 1 or it oscillates. If the cosmological constant is equal to λ_c, then the universe expands from a critical non-zero initial radius or it remains static at this radius, or it may expand to 0 asymtotically to this critical radius. And finally, if λ exceeds λ_c, the universe expands in the same way that it would if it were an open universe.

In recent years a great deal of attention has focused on so called Friedman models in which λ is assumed to be equal to 0. There are two possible types of Friedman models, open and closed. The closed Friedman models must necessarily oscillate, whereas the open models will expand in a decelerating manner. The attraction of the Friedman models is largely in that the equations can be solved explicitly. Sandage and Hoyle have shown that the curvature of a Friedman universe can be uniquely discriminated by the so called deceleration parameter. According as the deceleration parameter which is designated by q_o is greater than, equal to, or less than 1/2, the curvature will be +1, 0, or -1. Recently Sandage has shown on the basis of theoretical curves, constructed for Friedman models relating q_o to the magnitude redshift diagram, that the best fit of the data which includes radio galaxies and clusters but not quasars, corresponds to a q_o of 1.65. Since this value exceeds 1/2, k must be +1, the universe must be closed, and hence oscillating. In the Friedman universes a basic equation can be obtained relating three observables. This equation is $q_o = 4\pi g\rho$ divided by $3H^2$. Now q_o, ρ and H may all be observed. A few years ago Oort estimated ρ_o, the present density of the universe, to be on the basis of the density of galaxies and their distributions to be 3.1×10^{-31} gm/cm^3. The present value of H, the Hubble parameter, appears to be in the neighborhood of 75 km/sec/mpc. These two values in the Friedman equation demand a q_o near 0. That is an open universe. Sandage's value of q_o of 1.65 together with the value of 75 km/sec/mpc for the Hubble parameter leads to a density of the order of 3.5×10^{-29} gm/cm^3 or in the neighborhood of 100 times what Oort observes. We here have a serious discrepancy between the observed value of q_o and the observed density. We may assume that the value of the Hubble parameter is correct. It is difficult to account for the fact, if the value for q_o is correct, that we are seeing only one percent of all the matter in the universe, 99% being invisible.

A second difficulty which is encountered in these latest results of Sandage has to do with the time scale. Now the time scale is not a new difficulty in cosmological models. You will recall that during the 30's the value of the Hubble parameter as then derived by Hubble and Humison was such that the age of the universe, the Hubble time, was about 2 billion years and we had observed the ages of rocks on the surface of the earth which were of the order of twice that age. This interesting discrepancy gave rise to the so called steady state universe which did not get into this trouble with the time scale. However, later ___________ showed that the zero point in the calibration of the set of luminosity curves was in error and that the Hubble parameter had to be changed up to about five billion years.

This removed the difficulty with the time scale. But today, if Sandage's new values are to be believed, we are again in trouble with the time scale. The Hubble time corresponding to 75 km/sec and a q_o of 1.65 is about 6.5 billion years. For a q_o of .5, it would be 8.7 billion years. Recent work in stellar evolution and new observations of certain types of stars shows that to adequately account for these stars on the basis of well established ideas of stellar evolution would require a time greater than 20 billion years. This second discrepancy together with the density discrepancy may be resolved if we are willing to abandon $\lambda = 0$ universes or Friedman universes. There are two additional difficulties with the $\lambda = 0$ universes which we shall discuss later.

If we are forced to abandon Friedman models, then regretfully we lose the value of these beautiful tests of the curves which discriminate between open and closed universes according to the value of q_o. In other universes we must know the value of the cosmological parameter itself before we can distinguish between cosmological models.

It is proper at this point to say a few words about the steady state model of the universe, although at the present time there are very few who still believe that the steady state model fits the observations without introducing a large number of ad hoc hypotheses. The steady state universe requires a q_o of -1 and certainly Sandage's value of q_o exclude this particular one. But the steady state hypothesis is in difficulty in several other respects. For example, the counts of radio sources with distance show that the universe is not homogeneous as would be required by a steady state hypothesis. But worse are problems of how to construct galaxies which must be condensing in a universe in which all the new matter is expanding. The die-hards with the steady state model are now holding that the sample of the universe we see may be just one additional cosmic hierarchy and that the steady state holds in the large but in a large which is far beyond the capabilities of our instruments to resolve. The principal value of the steady state model has been its stimulation to cosmological research, and although the model was never on either theoretically sound grounds or observationally proven, it did contribute a great deal of ____________________ which lead to the development of cosmology.

The scientific dialectic consists of observing a paradox forming some sort of hypotheses to explain the paradox; testing this hypothesis experimentally or with further observations and if valid, proceeding to formulate new questions, or if invalid, formulate new hypotheses. Two situations are typical in the operation of the dialectic. The first situation is that which is represented by the state of meteorology. Here we have an abundance of data which has been collected over large portions of the earth over a great many years. The problem is to find a theory for the circulation of the atmosphere which will allow the weather to be predicted. It is felt that the observations are in advance of the theory because it is impossible to get a theory to fit the observations. Although the cry goes up continually for more and more data, what is really required is basic theoretical work. The second situation is typified by cosmology. In the case of cosmology, there are an abundance of theories concerning the origin and evolution of the universe, but too few observational check points to allow a decision to be made as to which of these theories are valid, and which may be excluded. Here what is required are more observations, and especially, more observational check points.

The observational approach to the selection of the homogeneous cosmological model which best fits the observed sample of the universe has been primarily based on the three Tollman Hubble tests; the counts versus redshifts, the diameters versus redshifts, and the magnitudes versus redshifts. In the case of a Friedman type universe in which λ is chosen to be 0 and the pressure is neglected, it turns out that discriminating observable which will allow us to decide which of two possible types of Friedman universe best fit the observable sample, is the deceleration parameter q_o. The deceleration parameter q_o, however, is of use in discriminating between cosmological models only in the case of the Friedman models. If it turns out that the cosmological constant λ is not equal to 0, then the q_o is useless for discrimination purposes.

Whenever a new observational check point becomes available which may be useful in a cosmological problem, a great deal of research effort is devoted to developing the new area. In the past two decades, three new possible observational check points have come into existence. I want to say a few words about these new observational developments.

The first development was radio astronomy. With the first detection of radio signals of a discreet nature from outer space, there was absolutely no knowledge as to their cause or how far away the source might be. The first problem in radio astronomy was to obtain a high enough resolution to get accurate positions of the radio sources so that they might possibly be identified with optical sources. The history of the first fifteen years of radio astronomy is largely history of improvements in resolving power and hence in the positions of the radio sources. Ryall was the first to point out that radio sources might possibly be at cosmic distances rather than being nearby radio stars within our own galaxy. At the present time, there is strong evidence supporting Ryall's view that a very large percentage of all radio sources are extragalactic. This is known largely through the identification of the radio source with an optical source. Until recent years, certain types of large or irregular galaxies were the best established radio sources. Astronomers in England and Australia principally were active in assembling catalogs of these radio sources. When counts of the radio sources to different apparent power limits were made, it was found that the distribution did not correspond to a uniform distribution in euclidean space, but seemed to fall off more rapidly with distance than is consistent with a -3/2 law. This problem put all forms of the steady state cosmology into a serious difficulty. To this day, no satisfactory solution to the distribution of radio sources has yet been found.

But one of the most exciting discoveries of modern times, and certainly one of the most exciting discoveries in the entire history of astronomy, came about through the compilation of the catalogs of radio sources and the obtaining of accurate positions for the radio objects. This discovery is all the more interesting because there is nothing in any existing theory which predicted it or even hinted to the existence of a new type of body which was first found in 1961 and which has since been called quasar. As a parenthetical remark, it is valuable to remind ourselves that our theories have not yet reached the point where they can continue to develop without the aid of observation. In the early 1920's, a very famour debate took place between two distinguished American astronomers, Curtis of the University of Michigan, and Chapley of Harvard. The subject of their debate was whether or not the spiral galaxies were nearby systems in our own galaxy or were actually external to the Milky Way. In 1923 this question was resolved by the discovery of cepheid type variables in certain of the spirals which definitely located them well outside the Milky Way. But at the same time this discovery was made a certain prejudice or set of ideas came into astronomy and this was that in order for anything to be outside the Milky Way, it would have to have an appearance something like a spiral or one of the other types of nebulae. The existence of stellar like objects that we could discern outside the Milky Way was dismissed. This is perhaps why the discovery of the quasars or quasistellar radio sources came as such a complete surprise. A slide which illustrates this situation shows a band which passes through the domain of all objects showing those which may be observed photographically. Within the band on the right are the faint galaxies,moving to the left, the bright and more concentrated galaxies. Further to the left of the second line are stellar like objects. It was felt until the discovery of the quasars that all objects in extragalactic universe which we could detect would lie within this band. Zwicky and his colleagues had observed near the left side of the band highly compact galaxies which showed wisps of nebulosity showing that they were not stars. These discoveries of Zwicky, plus some of his blue stars which had large redshifts, were the only clues we had that there might perhaps be something quite stellar-like in extragalactic space which we could detect. However, it is interesting, the fact that one star which had a very high redshift was explained by saying that it had fallen coincidentally on a line of sight with an extragalactic nebulae.

The story of the discovery of the quasars is one of the most exciting and romantic stories in modern science and I regret that we do not have time to point out some of its more interesting details. In brief, quasars were discovered when a very accurate position of one of the radio sources, 3C273, had been determined by astronomers in Australia by means of an occultation of the source by the moon. When this very accurate position was checked against plates made with the 200 inch telescope, it was found that there was nothing interesting like an unusual galaxy in the field; in fact, only one ordinary looking star was in the position indicated by the radio source. This was disappointing and about to be ignored as a coincidence when Sandage decided to investigate this star just to see whether by chance it had any peculiar properties. Color photometry showed that the star had a very large ultraviolet excess. In addition, the spectra showed that it had an extremely high redshift, .19, which definitely placed this star way beyond the limits of our galaxy. Hence, there was no question that what this very unusual optical object was associated with the radio source. As accurate radio positions became available several additional stellar-like sources were detected, and in each case, they had an unusual spectra, and an ultraviolet excess. The slide shows a so called three color diagram in which the color of the object in ultraviolet light minus the color in blue light is plotted against the color in blue minus the color in yellow. Most stars so called main sequence or normal stars lie on the solid curve which approximates a cubic curve. It was found that the representative points in the two color diagram of the quasistellar sources were in the upper right hand part of the diagram above a black body line or above even the white dwarfs and blue halo stars. The color diagram,once the characteristic region for these new types of objects had been outlined, served as a tool for discriminating between normal stars and quasistellar objects. However, the discrimination was not complete because of the regions where blue halo stars and quasistellar sources overlapped. In these cases the redshift would serve as the ultimate discriminator. The principal interest of the color diagram centers around the fact that a great many objects were found,far more than the number of radio sources suggest, which occupied the upper right portion of the diagram. This led Sandage to suspect that there was a large class of objects like the quasars which were radio quiet. Redshifts of some of these objects later proved Sandage to be correct and that there are large classes of stellar-like extragalactic objects whose nature and even distance is unknown.

The most challenging aspect of the quasars is the tremendous amounts of energy which they radiate. Of course, these amounts of energy depend upon whether or not our interpretation of the distance to the objects in terms of their observed redshifts is correct. One of the most exciting stories in connection with the quasars is the derivation of their redshifts by Schmidt. He found through a systematic analyses of different displacements that the unusual spectral characteristics of the quasars could be interpreted in terms of very high redshifts. He succeeded in determining these redshifts and found that for several objects, the redshifts exceeded two. This is quite startling in view of the fact that before the detection of quasars, the largest known redshift was hardly one-tenth this value. The question which is basic to the problem of the quasars is whether the large redshifts may be interpreted as cosmic redshifts in accordance with the law using the same value of the Hubble parameter which has been derived for galaxies. If this interpretation is allowed, the quasars are then at extreme distances, up to 500 mpc, and the energies that they emit in accordance with the inverse square law are of the order of 10^{65} ergs. The sources of such large amounts of energy are completely unknown. The second interpretation has been proposed for the redshifts that they may be due to some other cause than the basic cosmic redshift. As for example, they may be gravitational redshifts, following a model which has recently been proposed by Hoyle and Fowler, in which case the quasars would not be at cosmic distances but may be only a few mpc away though still outside the galaxy. The energies involved are no longer so large as to require any special or unknown mechanism. The quasars form a very challenging and difficult problem. The implications of a solution to this problem may reach deep into the foundations of physics and astrophysics. We do not have time to discuss the quasars per se today, but we wish to look at their implications for cosmology. If the redshifts are interpreted as cosmic redshifts, then certainly the quasars would be extremely valuable for discriminating between the various q_o curves. We would have points further out on these curves than any available from galaxies or radio sources by a factor of almost 10. So from the point of view of the m log z, Hubble Tollman test, what can be learned of cosmological interest from the quasars bearing in mind that we are assuming that the quasars follow the usual Hubble law. When the magnitudes of the quasars are plotted against the logs of the redshifts, we find a diagram with a very high degree of scatter as shown in the slide which is adapted from Hoyle and Berbiage. The points do not lie along a single line as in the case of the radio sources and the clusters of galaxies, but show the same sort of dispersion which is shown by nearby galaxies. It is evident that the quasars are not useful to discriminate q_o curves on the m log z diagram. This has been a big disappointment, that in finding large redshifts, hopefully would resolve the q_o selection problem. But of course, the discovery of objects with large redshifts may have far more profound and interesting meaning than that associated purely with the m log z curve. The resemblance of the distribution of the quasars to that of the nearby galaxies is one of the points in favor of the nearby hypothesis.

Very recently two new discoveries with regard to quasar redshifts cast large doubt over the interpretations of the redshifts as being purely of cosmic origin as associated with Hubble's law. These two discoveries are first, for all large redshifts greater than 2 for which absorption features are present, the absorption features are all very closely the same redshift, namely 1.96. The second property of the redshift is that recently Greenstein has found an object in which some of the lines have one redshift, and other lines have a second redshift. An object cannot be at one distance participating in one cosmic recession and show a split redshift of this sort. Finally, Streichnotter has shown that the distant quasars are closely grouped in two areas of the sky as though they constituted special systems of their own.

In addition to the discovery of the quasars, a second very exciting new observational check point has recently come to light. This is the recent discovery in 1965 by Pensius and Wilson that/at a wavelength of 7.3 cm, the universe appears to have a background temperature of some 3° Kelvin. This had been predicted theoretically by Dicke and Peebles at about the same time as its observational discovery. A value also indicating a 3° temperature background was found at 3.2 cm by Rolle and Wilkinson in 1966. Field and Hitchcock in 1966, Thaddeus and Klauser in 1966, have also inferred a 3° Kelvin temperature at 0.26 cm from the rotational structure of the interstellar absorption bands of cn. This 3° Kelvin temperature background is being interpreted as the vestigial radiation from an initial fireball and that the primeval photons associated with a temperature phase of something of the order of 10^{11}° Kelvin are now properly cooled to 3° K. The discovery of this radiation is taken as very strong evidence for the evolutionary theories regarding the origin of the universe and particularly to the Lemaitre type - primeval atom.

One of the most important cosmogonic problems is the origin of the elements. The basic problem is to fit the observed abundances of elements in the solar system and the abundances derived from observations of stellar spectra making use of the nuclear reactions including their rates and energies as determined in the laboratory. The elements may have originated in one or more of three different ways; stellar synthesis, that is, in the interiors of hot stars; in super massive stars, such as quasars have been presumed by some to be, that is objects of the order of 10^8 solar masses; or in a primeval fireball, in a big-bang evolutionary model. There are difficulties in deriving the heavier elements from stellar interior generation. The two favorite sources for building of heavier elements are the primeval fireball and super massive stars. One of the first problems concerns the origin of helium. In the sun about .27 of the mass is known to be helium, but this could not possibly have been generated in the sun, due to the carbon cycle or other processes going on in the generation of nuclear energy in the sun. A great portion of the initial helium must have been present when the sun was formed. Wagoner, Fowler, and Hoyle have shown that if helium is produced in a universal fireball, the mass fraction of helium which is produced lies between .2 and .3, which is determined using the present temperature 3° Kelvin. If the helium has been generated in super massive objects, then a much higher ratio, .4, could have been produced. It is hoped that by measuring the helium concentrations in different astronomical bodies it can be determined whether helium originated in the original fireball or in super massive objects. If the concentrations of helium are in general found to be as high as .4, this would favor the super massive objects as the site of the origin. If it could be shown, however, that the helium ratio is always near .27, as in the case of the sun, this would favor the universal fireball as a source of origin.

Wagoner, Fowler, and Hoyle find on the basis of fitting the observed abundances of deuterium, helium 3, helium 4, and lithium in the solar system that a model consistent with the 3° Kelvin temperature at the present epoch, and with a density of 2×10^{31} gm/cm^3, turns out to be an open cosmology with a deceleration parameter in the neighborhood of 5×10^{-3}. This seems to be the best model for generating the observed abundances, although Wagoner, Fowler, and Hoyle restricted themselves to models with vanishing cosmological constant. The time since the original fireball, in this model is from 10 to 13 billion years, still somewhat short of the 20 billion years required by stellar evolution. This complicates the problem for Friedman universes. The problem is even further complicated by the recent discovery of some very old stars with very low helium content.

It was mentioned initially that the best theory of gravitation which we have available is Einstein's general theory of relativity. The Einstein theory was given observational verification through the three famous Schwarzchild tests; the advance in the perhelion of Mercury, the deflection of light rays passing near the sun, and the gravitational redshift of spectral lines. The latter two tests are inconclusive for establishment of the general theory of relativity because they are either only qualitative or as in the case of gravitational redshifts, they are common to a great many theories of gravity. The test which singles out Einstein's theory of general relativity as the best candidate for a theory of gravity is the advance in the perhelion of Mercury. Observations show that Mercury's perhelion rotates approximately 5600 seconds of arc per century. If one uses classical mechanics to compute the rotation and includes the perturbations of Venus, Jupiter, Earth, Saturn, etc., the result is about 5,556 seconds per century. The difference between observation and Newtonian theory is 43.1 seconds per century and this seemed to be in almost perfect agreement with Einstein's gravitational theory which predicts 43 seconds per century. Recently, Dicke at Princeton, has questioned our right to ignore the oblateness of the sun as a perturbation in causing the advance in the perhelion of Mercury. If the sun rotates, as its surface features suggest, then the oblateness is essentially zero and there would be no oblateness perturbation. But if the sun has a core which rotates rapidly, as do a great many other stars, then there may possibly be some oblateness which would affect the perhelion of Mercury. Dicke set out to observe whether or not there was such an oblateness to the sun using a very clever type of solar telescope, in which he was able to remove most systematic errors. Dicke found that the fractional difference between the equatorial and polar radii of the sun was $5 \pm 0.7 \times 10^{-5}$ which indicates that eight percent of the Mercury perhelion precession may be due to a solar quadripole moment. Dicke's oblateness implies an eight percent discrepancy in the Einstein value. The value to be explained is no longer 43 seconds per century and the general theory of relativity no longer explains the observed discrepancy. Dicke announced, "It wouldn't surprise me if general relativity is just plain wrong." Dicke has his own theory of gravity called a scaler-tenser theory in which one of the properties is that the gravitational coupling constant G changes with time. He finds that the eight percent discrepancy caused by the oblateness of the sun is in perfect agreement with his scaler-tenser theory. So it may be that we are going to question the general theory of relativity which has been substantially on the books for forty years and have to revise our basic approach to cosmology.

The central cosmological problem in relativistic homogeneous cosmology, as was pointed out at the beginning of the lecture, was to select which of the seven generic types of curves fits best the observed sample of the universe. After using the various Hubble, Tollman tests, the arguments based on the origin of the elements and arguments derived from recent physical experiments, and from the presence of the 3° Kelvin isotropic background temperature, we cannot conclude that either an oscillating or an expanding Friedman model satisfactorily fits the observations. It appears that if we are to use the general theory of relativity at all, we must introduce the cosmological constant, λ, and that it must not be equal to zero.

Perhaps it is possible to make an argument which will allow us to isolate which of the curves best represents R(t) purely from consistency. The three Schwarzchild tests for general relativity were derived from a special assumption which is similar to the assumption of homogeneity, namely a perfect fluid which is homogeneous and isotropic. The equating of the interior and exterior Schwarzchild solutions to the field equations results in the prediction that there exists a bound on the potential which any gravitating system may have. This potential bound $\frac{GM}{c^2R}$ must always be less than one-half. In addition, if we measure the gravitational potentials of bodies available for observation, we find indeed that the potentials of stars, galaxies, and clusters, and higher order clusters, all have about the same upper bound, which is less than the Schwarzchild limit. Thus both theory and observation suggest that a basic property of the universe is a bounded potential rather than uniform density. What implications then does a bounded potential have for the field equations? It can be shown in a very straight forward way that if k = 0 or -1, that is, if the universe is an open universe, then a bound potential demands that the density vanish. That is to say that such universes are empty universes and therefore, of no physical interest. This would be so except that Charlier has shown that it is possible to construct a universe with a vanishing mean density, yet have matter present. This can be done by constructing a hierarchy of cosmic bodies. That is to say, we continue the hierarchal structure started by the of stars into galaxies, galaxies into clusters, clusters into second-order clusters, by assuming that this type of clustering continues ad infinitum. Such a universe would be able to have all the matter observed and yet have vanishing mean density. We therefore conclude that if there is a bounded potential as implied by general relativity, then if the universe is open, it must be hierarchically structured with an infinite number of hierarchies.

On the other hand, if the universe is closed if $k = +1$, the argument is somewhat to make, but it can be shown that λ must be greater than zero. This gives a fourth argument against Friedman universes, namely, there is an inconsistency between all Friedman universes and the existence of a Schwarzchild limit. It can further be shown subject to potential bounds equal to 8/9 or smaller that if $k = +1$, q_o is less than -1, and the potential is decreasing with time. If the additional assumption is made that the only physically meaningful pressures lie between zero and the pressure of a photon gas, $\frac{\rho c^2}{3}$, then $\ddot{R}$ in the neighborhood of the present epoch must be positive, that is, q_o must be negative. This leads us to the conclusion that $\ddot{R}$ must be positive for all future times and that the universe is accelerating in its expansion to infinity. The ultimate state of this universe is described in the limit as t gets very large the deceleration parameter goes to -1, the Hubble parameter will go to a quantity which is equal to the velocity of light times the $\sqrt{\frac{\lambda}{3}}$, the pressure will go to zero, and the density will go go zero, and the potential will continue to decrease. This is a universe consistent with the second law of thermodynamics.

In the available patterns of R(t) three have the property of accelerating expansion to infinity. One of these is a contraction to a minimum different from zero followed by an expansion. The second is the Lemaitre Eddington pattern which starts at a value different from zero and expands in an accelerated manner to infinity, and the third starts from zero, decelerates, then accelerates in its expansion to infinity. So on the basis of self-consistency, we have reduced the problem of the selection of cosmological models to which of these three cases best fits the observable and derived parameters. This is equivalent to deciding whether the cosmological constant is less than, equal to, or greater than the critical value of the cosmological constant which corresponds to the gravitational radius of the universe raised to the -2 power. We must thus decide whether the universe is open or closed on the basis of whether the number of hierarchies which exist are limited or infinite. If the number of hierarchies terminates we can then take k = to +1, if not, then k must be equal to zero. Observations show that if the present trend of the numbers of particles in each successive aggregate is continued, that there can be no more than third ordering clustering which would suggest that k = +1. If we make the additional assumption that the total mass of the universe remains constant, it is then possible to show that the universe which expands from a singular condition that is, radius zero, is ruled out and the only possible universes left to us are the Lemaitre Eddington universe expansion from an Einstein static universe, or the universe which contracts to a finite value and then re-expands.

Hence in any event, under the assumptions of the validity of the general theory of relativity and of consistency with the Schwarzchild solution to the general theory of relativity which implies a potential bound, and on the basis of a finite order of clustering, the future of the universe is uniquely determined. It will continue to expand monotonically and in an accelerated manner for all time. Two paths are available to us; contraction to a finite radius then expansion, or expansion from a state of finite radius, which the universe occupied for an indefinite time. Whereas the field equations may be valid for predicting the future, since gravity undoubtedly is a dominate force for universes of low density, the validity of the field equations in the past is open to serious question when other forces than gravity may have played a dominant role. So the cosmological problem, as far as homogeneous models go, can be considered solved.

10-14-68

THE CRISIS IN MEANING

by

Albert G. Wilson

(Presented to Institute on Man and Science, July 4, 1968)

We have been concerned during the past few days here in Rensselaerville with views of some of the critical problems that engage us in the 60's, problems that may overwhelm us in the 70's. We have been reminded of some of the critical ~~un~~imbalances we have created -- ~~un~~imbalances not only in the distribution of sustenance, but in the distribution of hope. We have been reminded that the ~~un~~imbalances man has effected within his social order are now beginning to spill out and create ~~un~~imbalances in the ecology and even threaten such contexts as the atmospheric balance that keeps this planet habitable.

A picture has been painted for us of a society moving toward robbing increasing numbers of its members of meaningful roles in that society. Fewer people are needed in the economic sector. Old people no longer have a place in the family. Young people find little satisfaction in devoting themselves to learning the techniques of competing for spots in a social order that to many has no apparent meaning. They are finding even less meaning in the role of cannon fodder. Minorities when given ad hoc jobs to make more unneeded consumer goods do not receive a sense of relevance for their toil. Even worse -- the tacit diploma given with each welfare payment reminds the recipient that he has been graduated to the sector of society that no longer possesses social usefulness. However, he knows he will perhaps continue to be supported -- at least until a "pragmatic philosophy" can be derived that will allow society to find a realistic <u>final solution</u> for him. Even the slave had more dignity -- exploited though he was -- at least he was needed by society. In looking for a common ingredient in most of these trends, we see for many individuals the lack of a role, the lack of a needful relationship, the lack of meaning.

But the fact that society no longer needs large sub-portions of itself to assure its maintenance and continuation is only one phase of the growing crisis in meaning that marks these times. Economic meaning is only the most recent source of meaning to dry up. Other sources such as some religious sources that have long supplied meaning to many individuals have also dried up. Begin here

Before we turn to the broader aspects of the crisis in meaning, let us inquire into what <u>are</u> the sources of meaning for a man and for mankind. What do we mean by meaning? Without going into philosophical depths and details, we may simply say that meaning for an individual, for a society, for mankind as a whole derives from a sense of identity and a sense of belonging. For there to be meaning implies there is a role to be played, a task to be done. For there to be meaning there must exist a relationship between the individual and the other, such as the relationship of need between members of a family. For there to be meaning there must exist a linkage with the environment, or a function in the ecology. In general, meaning implies connection with context -- relation to past and future.

I am well aware that in making this great leap from the psychological, subjective "sense of meaning" to the structural, objective "relation to context" we have short circuited many steps that require careful discussion. But our purpose here is primarily to illustrate that for humans -- individually or in toto -- meaning derives from the existence of a set of contextual relationships. It follows that those forces or situations that remove or obscure contextual relationship or that obliterate function in the environment tend to erode the sense of meaning.

We have remarked the destructive effect of many of our economic and social trends on the sense of meaning for the individual, but there is another critical -- though less visible -- meaning problem with which all men in the 20th Century are involved. This is the meaning of mankind itself -- man's cosmic meaning. The role of man in the cosmic order. The relation of man and his works to the cosmos.

Men can live without this latter type of meaning for longer periods than they can live without individual meaning -- but not indefinitely. In fact, one of the principal questions of youth today is concerned with this larger contextual meaning for human society.

We may develop elaborate theories of social evolution and historical process based on our own aspirations or on our interpretations of whatever historical, paleontological, or geophysical records are available to us. But whatever system we develop, whatever plan we make, or dream we dream, must ultimately be tested for consistency with the contextual cosmic processes.

The ancients were well aware of the necessity to relate their existence and their affairs to the cosmic context -- perhaps because the cosmic context frequently intervened in their affairs in a cataclysmic manner. As an essential ingredient of their religions they introduced what we may call a <u>cosmography</u> -- a description of the cosmic environment and man's place in it.

Now it is essential to distinguish between the religious <u>Cosmography</u> and the secular <u>cosmology</u> or scientific cosmology of today. These two descriptions of cosmic context are primarily distinguished by the <u>questions</u> to which they address themselves and but secondarily distinguished by the <u>answers</u> they supply.

Traditional Religious Cosmography is concerned with questions such as:

What is the Universe?

How did it originate?

What is its destiny?

What is man?

What is man's relationship to the Universe?

We see these are basically "meaning" questions -- "why" questions.

Scientific cosmology is concerned with questions such as:

What material bodies exist in the Universe?

What physical processes govern these bodies?

How did these bodies originate?

What are their evolutionary paths and ultimate destiny?

What is their relationship to one another and to the whole?

These are "what" and "how" questions. Though there is considerable overlap, the questions of Traditional Cosmography are the essential, timeless questions bearing on human meaning. They are found in all cultures -- primitive, without what we call scientific experience and advanced, ~~on~~ those with scientific experience. They do not arise from sense experience or rational thought processes. The questions Traditional Cosmography seem to arise from the integration of total experience, directly from the psyche of man in his search for meaning.

In contradistinction to the universal questions of Traditional Cosmography we find the questions of scientific cosmology to be specific and much more restrictive. The questions of scientific cosmology reflect the emphases that the current age places on the material aspects of the world. The specific questions derive from a long sequence of observation and theory building and are a measure of our level of understanding of the material contents and processes of the universe. But because of overlaps in the questions of Traditional Cosmography and scientific or physical cosmology, such as origin and destiny questions, the two areas have been confused and have come to be thought of as a single discipline. This has resulted in a peculiar and in a sense tragic development in Western thought.

We have pointed out a Cosmography is an integral part of every religion. The nature of cosmic context supplied by Traditional Cosmography through myth, through constructs relating heaven and earth, man and gods; through creation stories,, have been a most important vehicle for giving a sustaining sense of meaning to man and to mankind. The Cosmography explained for man his peculiar relation to the universe, his special role in the universe, and his uniqueness as a creature. So important is the Cosmography to a religion it may be argued that a negation of the Cosmographical tenets of a religion results in the erosion of the efficacy and usefulness of the religion.

The contradiction of the Medieval Cosmography that placed God, omniscient and omnipotent, on a throne in Heaven directly over Jerusalem began a crises in meaning that has been troubling Western man. Western religion has retreated toward being essentially an ethical system centered about a secular institution, and has abdicated to Science the answers to the questions of cosmic context.

Today's <u>crises in meaning</u> is in part traceable to the divorcement of Cosmography from religion and the view that scientific cosmology will in time find the answers that will restore meaning to man.

Where do we go from here? If man's cosmic meaning derives from his role and his relationships to the cosmos -- what does scientific cosmology tell us about relationship between man and his cosmic environment -- what role does it indicate may be his.

An inventory of the known linkages between man and cosmos gives:

1. Gravitational Fields

   Tides, Time 24 hour $24^{h}\ 50^{m}$, 28 day

   Biological clocks - Astrology

2. Various types of electromagnetic radiation

   a. Solar terrestrial relationships

      Solar flares, radio communication

   b. Other radiation sources

      The two Universes - normal - explosive

      Supernovae and evolution

      1054 - Danube

      Cataclysmic events may be more common

3. Infall of cosmic dust

   The weather

The most important question concerning a possible role for life and intelligence in the universe is to ask how common is life and intelligence. Are we alone?

Fermi and the bomb

Ozma

Pulsars

History

(4)

Signals

i.e. Cosmic meaning cannot be found in todays cosmology

UFO

Compte and atoms

We conclude that the present state of scientific knowledge concerning human-cosmic relationships does not provide us with the materials for discerning our cosmic meaning.

We must accept that the path out of our meaning morasse is to pursue the unifying principles linking the physical and non-physical worlds that man bridges. Man cannot exist in part, divided against himself. He must acknowledge and accept his total essence. Nor can the clock be turned back. The ancient cosmographical relations between man and the cosmos that were once taken on faith can never be reposited for 20th century man short of their scientific verification. Man must now seek the verifiable relationships and a cosmically defined role. At this particular time, in his partial incomplete knowledge, he may feel cut off from the cosmos and doubtful of possessing any role in the cosmos.

All we can do is continue the search we have begun. It may be a long search; it will certainly be a lonely search. At the end may lie the discovery that man has no cosmic role and no cosmic meaning. But in the process of the search he will have perfected the tools of search. He will have developed skill as a searcher. And paradoxically in searching for a role, he will have developed one. His role will be the role of the searcher and in the search itself he will have found his meaning. Certainly this role is dignified and challenging enough for man until his true role is found. It is dignified and challenging enough for all time if no other role is ever found.

Rough Draft
A. G. Wilson
11/13/68

SYMPOSIUM ON HIERARCHICAL STRUCTURE IN NATURE AND ARTIFACT

INTRODUCTORY REMARKS - 18 November 1968

In coming together to discuss hierarchies, we are taking two risks. The first risk, since we come from various disciplines,each of which has developed a highly specialized language of its own, we encounter the risk that we are not going to be able to communicate with each other effectively. However, if we all tend to emphasize concepts and take the pains to explain the terms which to us have become everyday in our own usage but to a colleague in another field may require a moment's definition, we can overcome this difficulty in specialization. The second risk that we take is that in coming together to talk about a term which has not been well defined, the term <u>hierarchy</u>, we may find that we are not going to be talking at all about the same thing. Some of us will be talking about one type of hierarchy, and some of us, about another. Some of us will be talking about levels in a general sense, and some in a restricted sense, and we shall mean different things by the concept of level. Many of our ideas will undoubtedly prove to be wrong, and some, hopefully, right. Parts of our subject will necessarily have to be treated naively and superficially. Parts, perhaps,we can treat more sophisticatedly, perhaps, even with some profundity. But in a conference such as this designed to launch more extensive and intensive studies of hierarchies, it is proper that we be open to all ideas, orthodox and radical. For some time, we have been regarding the subject of hierarchies from the viewpoints of our diverse fields and we have undoubtedly developed quite different approaches and viewpoints of hierarchy. But it is this very fact which makes this conference timely and which is likely to give us a greater richness in our understanding of the subject of hierarchy than had it been approached from only one point of view and out of one discipline. However, this sets for us a grave responsibility. We do not know at this time what paths may prove fruitful in the future; therefore, we must not be too quick to agree; we must each nurture our own ideas for some time further, but profit by the exchange lest we cut off apparently less promising concepts too soon and establish some sort of party line for the study of hierarchies. One of the values of this conference will be tutorial; we all stand to learn a great deal in the exchange. Another advantage will be an accumulation of a set of examples which will illustrate the various conceptual points that we are developing. Perhaps beyond these two gains from this conference we may gain nothing except meeting new friends and establishing new channels of communication. On the other hand, there is always the hope that out of a conference such as this we may stumble across one of the basic unifying principles of science.

The fact that we come together not being discipline oriented does not mean we are transcending specialization. We are specializing in one particular relational pattern that we are calling hierarchy. Disciplines are usually divided according to the specific subject matter discussed. Recently, conferences have been held not divided by the discipline, but by the relational aspects. For example, we may cite the symposium on "Inter-disciplinary Perspectives of Time," held by the New York Academy of Sciences, January 17-20, 1966. We may cite the symposium on "Methodologies," held at the California Institute of Technology, May 23, 1967. So we are in the main current of a trend when we are beginning to look not at the specific objects of our study, but at the commonality of the relationships that exist between these objects. But in another sense, it is not what we view that is different from how we have viewed it in the past; the difference is in our approach, the difference is in the eye of the beholder. In a deeper sense, we may ask what is the difference between a disciplinary approach and a relational approach. If a disciplinary approach is to study the modules out of which the universe is made, the atoms, the molecules, the crystals, the stars, the cells, or whatever, and a relational approach is to view the universe from the relations existing between these modules, are we really talking about two different approaches, because on one level, a module is but a set of relationships between a module on a lower level. So in this sense, a disciplinary approach and a relational approach are the same thing. How then, is this conference different from a disciplinary conference? It is primarily different, not that in what we view is different, but in that we are taking an over view. Or we might say it this way: a disciplinary approach is to enter a subject on the level of a level. A relational approach is to enter a subject on the level between the natural levels. So our difference is one of resolving power.

Behind a meeting such as this is the possible motivation defined a new paradigm in the sense of Kuhn for science -- a new way of looking at things.

Finally, the goal of this conference becomes similar to the goal of any discipline oriented scientific conference. We will want to find what the different aspects of our subject, hierarchical structure, are. So that when we come together in the future, we will not come together purely as hierarchists, we will come together as specialists in different sub-branches of the field of hierarchical structure. We will come together, say, as repi-tactic hierarchists, or as meta-tactic hierarchists, in the fields that are yet undifferentiated and yet uninvented. But we will finally have established ourselves as a science when we have come to the point where a well defined hierarchical "pecking order" has been established and the meta-tactic hierarchists begin to snub the repi-tactic hierarchists. Some say that hierarchy is not a science. The final test will probably be whether it evolves in the truly scientific manner as just described.

A. G. Wilson, 2/4/69

I. INTRODUCTION: THE CONTEXT OF COSMOLOGY

COSMOS and MAN

A generation ago an astronomer addressing an audience such as this on the subject "The Cosmos and Man" might begin by describing the universe as our giant telescopes reveal it to us. He would speak of tremendous distances -- hundreds of millions of light years; of staggering masses -- 10^{11} suns; of fantastic energies 10^{45} ergs/second, of incomprehensible numbers like 10^{78}, the number of particles in the universe. He would then point out how minescule is our own earth in the cosmic scheme, how insignificant man is, and how inconsequential are his greatest efforts and achievements. The vast universe is utterly indifferent to us and our puny efforts. Even if we were to blow the earth to bits, beyond a faint brief flash of light rushing past the distant stars, hardly a ripple in the cosmic sea, it would make no difference to the remainder of the universe.

Most of us have heard such talks. They represent the ultimate triumph of the overthrow of pre-Copernican geocentricity. They summarize the mental achievements of generations of men committed to total <u>objectivity</u> and to the obliteration of "anthropocentric viewpoint" of the world.

Cosmology with more or less this flavor has been preached by physical scientists for a great many decades. They have been listened to by generations of students who have absorbed the indifference of the universe and the role of chance as universal first cause.

And now a question: Could it be that today's society, beset everywhere with the disease of alienation -- rich from poor, black from white, young from old, man from his soul -- could it be that all these alienations derived from man's belief in his own insignificance, in an indifferent universe, from belief in his being a creature whose origin was in the chance synthesis of an animo acid molecule; and whose destiny -- whatever it be -- is of no consequence. Are all of our immediate alienations in some way related to our ultimate alienation -- the alienation of man and the universe. The question of this ultimate alienation is one theme I hope we can explore tonight. But there are other related questions.

Today in speaking to the title "Cosmos and Man," it seems more important to analyze the relevance of our cosmologies to man than to discuss the relevance of man to the cosmos. It may seem a bit paradoxical, that in order to speak meaningfully about the Cosmos, which is the context for all of man's activity and which supplies the boundary conditions for man's existence, we should first speak of the human context in which our ideas of the cosmos must be imbedded.

This paradox takes on a cogent and immediate guise when cast in the form of the United States Space Program. The NASA has been quite concerned in its Public Relations Program with the feelings of many on the inappropriate use of tax dollars for circuses in space when bread is lacking on earth. The NASA PR people have emphasized the scientific importance of their program. But only a few people can get turned on with a better determination of the atmospheric pressure at the surface of Mars or the temperature gradient in the atmosphere of Venus.

METATAXIS: The Science of Structure*

Albert Wilson

In the past quarter century, change in our environment has become what we can call an increasing technological backlash. No longer can we equate technological advance to progress, if progress is to be measured in terms of the welfare, happiness, and aspirations of mankind. The search for control over the forces of nature has resulted in unleashing a set of forces that increasingly constrain and threaten us.

Technological advance in our culture is characterized by two procedural modes: i) Doing what is feasible or possible with secondary or no consideration to whether it is useful or needful; and ii) Developing products and systems in isolation from the context of their utilization and without regard to their relevance to human goals, their affect on the ecology or their accumulative interaction with each other. It has even been suggested that technology has become autonomous and leads a life of its own — an existence beyond human control. This reductionist approach results in a rampant evolution whose emerging creatures are, at minimum, unbalanced and absurd and, at maximum, threatening to human health and survival.

In the choice of what problems to solve and what technological systems to build, feasibility and reductionism have spawned a set of new problems — super weapons, pollution, congestion — that redictionistically oriented science and technology cannot solve.

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*Second lecture of the Spring Lecture Series of the Design Department, Southern Illinois University, Carbondale, Illinois, 19 May 1969.

This situation is unacceptable, but its causes have not been rejected. Even in the proposed solutions of the problems created by the random application of technology, the same random and reductionist philosophies are employed and absurdities are compounded. To offset the threat of ICBM's, we plan to add the threat of ABM's. To overcome the threat of passengers brandishing pistols in airplanes, we propose arming pilots and stewardesses. To counteract the local unleasing of violent forces through dissent, we support technical riot control and massive means of crime suppression. We are desperately in need of solutions that do not continue to contribute to the problem.

In identifying reductionism, choice by feasibility, and the random unstructured allocation of resources and research energies as the central features of the evolutionary process of our scientific-technological culture, we are led to examine their origin and derivation. These processes have come from the logical growth of philosophical ideas deeply rooted in Western thought — from the epistemological canons of Aristotle and Bacon, from the spatial concepts of Descartes, from the temporal concepts of Newton, from the reductionism of Locke, from the pragmatism of Peirce and James. It is disconcerting to behold that the sources of our problems stem from the level of our most basic beliefs. The proud heritage of Western thought has been tested in a new millieu of its own creation and it does not work. This situation must precipitate a revolution far more extensive than the Western World has ever encountered; a revolution that we are not only least prepared to acknowledge no only least experienced to effect.

This revolution must be conducted on a level no more superficial than that of finding entirely new ways of looking at the world. Before new solutions and a broader spectrum of choice can be opened, we must break the molds in which our patterns of thought are cast. To do this, we must become conscious of the tacit assumptions underlying our most basic ideas — our core beliefs. We must look at all alternate patterns of thought available to us to find where the tacit assumptions lie. To find new 'weltanshaungs' that do not force us into phenomenological denial of large sectors of our own experience, we must enter and re-explore the realm of meta-knowledge. We must study the epistemological modes that govern how we process experience and structure knowledge.

To do this we must not only look at the organization of knowledge by disciplines and curricula, we must look at alternative modes of structuring experience, at meta-logics and at meta-epistemologies. We need a word broad enough to cover all aspects of this investigation. We adopt "METATAXIS" to mean the structures of structuring and the processes of processing.

While we enter largely unexplored territory and successes, if any, will be difficult to come by, the rewards promise to be high. In outlining as theory of structure, we are discussing the problem of change and how it relates to the obsardities facing our society as a whole. Let us repeat what it is we seek. Metataxis is the identification and systematization of relations common to various general classes of structures and processes. In this effort, we view structure and process from different levels of abstraction and look for laws that govern both horizontal and verticle relations in the various modes for structuring experience. This is a tough assignment and we must forge our tools along the way. Tonight we can do no more than point the direction so before we proceed further on specifying a science of structure, let us look in more detail at the attack being launched against the dehumanizing trend accompanying the growth of science and technology. This world wide rebellion which is usually identified as the adolescent fringe of flower-power and student insurrection on the street also includes an increasing segment of the intellectually community — even some scientists. Its idealogy places it squarely across the path of the traditional goals of science and technology. The retiring president of the American Association for the Advancement of Science, Don Price, just recently wrote that "from the point of view of scientists, the most important theme in the rebellion is its hatred of what it sees as an impersonal technological society that dominates the individual and reduces his sense of freedom." (Science, 3 January 1969, p)

Other philosophical spokesmen of the new rebellion summarize their position as follows: First, Andre Malrau says, "The most basic problem of our civilization is that it is a civilization of machines and that we for the first time have a knowledge of matter and a knowledge of the universe which suppresses man." Another, Jacques Ellul, one of the foremost in pointing out the trend in which the technological society is moving, "Scientists have become sorcerers who are totally blind to the meaning of the human adventure." He further feels that the system of thought which has risen from scientific thinking is, "Bringing about a dictatorship of test tubes rather than hobnailed boots." Eric Fromm says that, "Technical progress has become the source of all values and we see in consequence the complete alienation and dehumanization of man." But the most prominent of philosophical spokesman for the rebellion is Herbert Marcuse, and he has perhaps struck closest to the fundamental chord whose resonance spurs the dissent, "The mathematical character of modern science determines the range and direction of its creativity and leaves the non-quantifiable qualities of humanitas outside the domain of exact science." Perhaps it might be more accurate to say that the type of abstraction used by modern science, particularly the reductionist type, forces the bulk of relations that are the essence of human experience to be left out. The villian thus becomes not science but something underlying science, namely the epistemological base upon which scientific thinking is built.

The reductionist system of thought derives primarily from the works of Locke who gave it its modern expression. "Lockean reductionism operates in at least three ways: what is small and molecular is more fundamental than what is large and molar; what is external and visible is somehow more important than what is not; and what is earlier in development is more basic than what comes later." Paul Weiss summarizes the doctrine of reductionism as that which axiomatically prescribes that all the relevent macro-information about nature must, and eventually will, be derived completely from adding up and piecing together the microinformations about the smallest sample units.

Reductionism has come to mean a system of thought which stresses analysis and looks for the explanation of every phenomenon within its constituent parts. The flow of causality is from small to large. Reductionism, accordingly, fails to search for contextual relations. Its emphasis tends to ignore the millieu in which a particular problem is embedded, and thus in our crowded world in which the interrelations between all facts of society become more intence, where contextual relationships have a higher release, the failure of the reductionist approach becomes more visible.

Buckminister Fuller in his recent letter to Doxiades (Main Currents, March/April 1969) summarizes the redictionist attitude in education: "... today's primary educational systems, all around the world, start the children's would-be education only with elementary parts of subdivisions, which never explain the holistic behaviors and thus imply that science and technology may only be successful as a myriad of separate intricate specializations, never subject to unified comprehension by one mind. Specialization (and today's chain reaction of self-accelerating fractionation of all thinking) resulted from the old master pirates', pre-World War One synergetic strategy by which they required that all the bright lieutenants and experts must confine their labor and inquiry to differentiation, and that each must mind his own business and must eschew all integration, which was the old master pirates' exclusive prerogative. Thus, the elementary educational system, which starts exclusively with a few parts or elements, leads at best to differentiated statistical probability based entirely on the separate behaviors of those elementary parts. Probability, the strongest tool of statistics which deal only with parts, at its best is a weak tool.

But before turning from the critique to the problem of developing new tools to imagine new futures, we must also answer those who are opposed to all structuralism. Sartre and his followers hold that structure limits our freedom and conditions our choices. He claims that "we must study the reality of our freedom, not the complexity of our limitations. Life is action, not apologetics." (MANAS 1969). But David Michael Levin answers Sartre by saying, "Structures are the natural expression of freedom, although, to be sure, their advent necessarily amounts to a certain 'inhibition' of this freedom. But such inhibition is no different, in fact, from the way in which a language might be characterized, in a dramatic way at 'coercing' the thoughts that it is intended to express." (American Scholor, Winter 1968-69). Thus Levin's argument follows the viewpoint that structuring increases the spectrum of choice just as language increases the possibilities to formulate and communicate ideas.

But we must also be aware of what we are doing when we structure. Levin goes on to explain our continued respect for the judgments of Sartre because "we can sense, as the motive behind his outrageous pronouncements, a terrible fear which our own hearts respond to: Sartre is sage enough to perceive than any understanding, based on the concept of structure, can readily lend itself to reactionary or malevolent ends. Any such understanding can deftly conceal the possibility of living choices ... if freedom is not to remain a mere abstraction, a metaphysical state or essence, then it must be accorded the power that comes from a mastery of the forms of life, such as they are; and this, in turn, challenges man to understand both himself and his world in terms of their significant structural properties ... Sartre's repudiation of structuralism on the grounds that it denies freedom in the name of reason, is thus completely misguided. Science, as the highest stage of self-consciousness, is an essential condition for the possibility of freedom." It isn't structuralism that forges our chains, but the making of structures into fetishes that binds us. Its the inability to de-structure or break down the idol when its usefulness is outlived that takes away our freedom. There are some cultures — the Mayan or Aztecs, for example that had ritualistic 'smashing' of the idols every fifty-two years to remind themselves of the necessity of restructure. This is what we need, a re-structuring of our concepts, our models and our gods. But how do we design a new mold? Where do we go from here? We might say that ultimately we would like to have an axiomatic system — a series of axioms and postulates on general structure that is more specific than set theory and more general than physics. But if we push immediately into axioms, we may be getting too specific, too soon and fall again into a reductionist trap. If ignoring of context, focusing only on detail, and narrowly specializing is a factor in our illness, we must design our new tools so as to avoid this pitfall. Not that reductionism doesn't have its place, it does, but here I need not go into its proper use. You can hear about it in other places every day.

We must begin by being encompassing rather than penetrating; by being comprehensive rather than detailed; by being complete rather than perfect. In other words, we must use lenses of wide field rather than high resolving power. Another way of putting it if you prefer, is that the feminime principle must be brought forth and the masculine principle pushed to the background. At a recent scientific symposium, FAITH, SCIENCE, and the FUTURE

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LECTURE GIVEN AT CALIFORNIA LUTHERAN COLLEGE 197~~9~~1

~~Three~~ Seventeen years ago our country celebrated the beginning of its third century ~~as a nation~~. Our present government has one of the longest periods of continuous existence of any on earth. This is not an accident. Preceding the key year in history whose bicentennial we just recently celebrated, there was a decade of extensive and intensive debate. The taverns and the coffee houses were filled with men questioning and arguing the rights of citizens and the limits of governments. The creative events that we associate with the Founding Fathers were not the results of lobbying, plea bargaining, or back room deals. They resulted from constructive dialogue and searching debate concerning not only the pragmatic but the philosophical issues that underlie social and political order. reword

When it finally became evident that the alternatives open to the colonies under the Crown were not acceptable, a long search began for a different set of alternatives. ~~--alternatives without the Crown~~. It was an intellectual tour de force to come up with ~~new~~ solutions to the problems of colonialism, federalism, and the legitimization of revolution. It was an even greater tour de force to devise the concept of a constitutional convention and to derive from it the framework in which the new alternatives could viably operate. This came about only from the exploration of the foundations on which human social orders are built.

~~Today, two hundred~~ More than 200 years later we are faced with a parallel situation. It is becoming increasingly evident that the alternatives open to us within the constraints imposed by our present institutions, present practices and present ways of thinking are not viable, and that we too must seek a broader set of alternatives--those afforded by a new worldview. It will again require an intellectual tour de force to find a worldview that will supply both the needed alternatives and the framework for their realization. We shall have to explore not only the structure and purposes of institutions and procedures, but the values and the images on which they rest.

But already our own decades of ? dialogue have begun: Is zero growth possible, can we devise an accounting system that will reveal to us the total costs and benefits ~~, including environmental ones~~ of zero growth or current practices? Renewable vs. non-renewable energy sources, Small is Beautiful --all are being debated. We read about the dialogue in books such as Erich Jantsch's Design for Evolution, Ervin Laszlo's Strategy for the Future; We hear the dialogue at meetings such as that of the World Future Society where a prominent senator reminds us, "Only those who actively engage the future will be empowered to shape it"; and we participate in the dialogue in a series such as this one on "Faith, Science and the Future". I feel it quite reasonable to say that the searching dialogue of our time has grown up with, and is centered around a

new / update the examples

question

new concern for the future. Voltaire's, "Why should I be concerned for the future, what has posterity ever done for me?" is being replaced with,"You had best give thought to the future, that is where you will spend the rest of your life." by whom?

who is "me"?

While no new worldview has yet emerged--and we cannot expect one to appear overnight--already our level of consciousness has risen and we are effecting important modifications to our approaches to problem formulation and problem solving. We are discovering what is more basic, and are re-ordering, our priorities. We are rediscovering the role of values—which an exaggerated sense of what science could do for us had put aside—and we are learning the importance of assessments made in advance. We, in one or two instances, have even achieved the maturity to forego doing something just because we could do it. But an uncomfortable suspicion is emerging from the dialogue that we have been misled by our current worldview. It does not tell us who we are or what the world is really like. The so-called Enlightenment Worldview, the worldview derived from the work of Descartes, Bacon, Galileo and Newton, is now falling apart under the most recent discoveries of science as well as from its failures as a foundation for the social order. This worldview is playing the role of the Crown. interesting

Time does not permit us on this occasion an elaboration of this metaphorical identification of the present dominant worldview with the Crown. We have all heard the superficial attacks made on science and technology by hippies and neoluddites, and the more responsible charges leveled by scholars such as Theodore Roszak.

update rel. concern over criticism of itself

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These are times characterized by rapid change. In writing more and more on each page, ~~we in some way press through the page and also write more and~~ more on the pages of the future. This pollution of the future destroys a very precious possession. It destroys our option space. The number of options and choices available to us decrease each year until we shall become totally without options--totally determined, like the path of the stone dropped from the Tower of Pisa, or the ball rolling down the inclined plane --totally predictable, just as the Enlightenment worldview has pictured us. Man, originally not a machine, but through centuries of thinking of himself as one, becomes one. We fulfill and become our self images. ? confusing

appears to conflict with par. 1 this page

Today our executive decision makers are not free to devote time to the initiation of new projects. They must give their full attention to crises that have been written on this page of history by our actions of the past 30 years. The loss of options ~~space~~ is visible in our having become consumed with crises--sequences of events ~~which~~ that demand response. There are no longer the options of initiative, only the options of response. And even these options are decreasing, and soon there will be no longer be even response, only reaction. We become the dropped stone.

These ideas may also be expressed in terms of the language of archetypes. When one has fallen into an archetype, freedom and options are gone. All that remains is to live out the archetype, play out the pre-written script until the curtain comes down. The planner of the future--and each of us is a planner of the future--finds himself or herself increasingly frustrated and uncertain with fewer and fewer options and less and less freedom. The pages of the future become completely filed in and there is no space in which to write. we can only read what we have already written, only live in the world which we have been building through the past choices ~~we have made~~ ~~which~~ that ~~have been~~ destroy~~ing~~ our future choices.

In the non-metaphoric sense, what we have been talking about may be described by two phenomena: The first of these is the effects of the aggregation of an ensemble of individual plans. Our society moves in the direction statistically determined by the interactions and cross impacts of all of the many microplans developed by each center of enterprise--the personal plans of each of us. The macroplan is the sum of the microplans.

What we are discovering is that, though each microplan may be directed toward what the microplanner perceives to be an improvement in his personal world, the aggregate resulting macroplan is not going where any of us wish. The unplanned consequences of our many plans lead us to the realization that no one is really in charge. There are no bad guys--just ourselves.

Since we cannot alter the laws of aggregation, how the microplans add to make the macroplan, we have two choices:

The first is to opt for a dictatorial centralized authority to do all of the planning. The Big Brother route. But this doesn't work either. The economy of the Soviet Union is in more trouble today (1979) than is ours. We cannot expect to solve the problem merely by doing more efficiently things which do not work in the first place. update

The other option is to change the microplans and to do this the microplanner must change--that is, you and I have to change. And the key to our changing is a new worldview a new self image. A new definition of success--~~one~~ not based on the extent of one's possessions; A new definition of personal meaning--~~one~~ not based on consumption of goods and services; A new interpretation of pursuit of happiness--~~one~~ not based on the material~~istic~~ ~~worldview.~~ ? reword

need example

The second phenomenon reducing our options ~~space~~ is our inability to perceive certain feedback signals. In other words our systems have become uncorrectable. There are several reasons for not perceiving a feedback signal. One of these is that the define for reader signal is too weak or increases too slowly. There are the FROG BOILING and SMOG examples. Another reason is that the signal is delayed in time. There are the HOT STOVE and CANCER FROM RADIATION examples. When the consequences of our actions are not perceived in time, it is impossible to stay on course. The problem thus becomes, you cannot get where you want to go, not because you don't know where you want to go, but because you don't know where you are. describe for lay reader

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Just as there was knowledge of America in both Asia and Europe prior to Columbus, so there is knowledge in both East and West of the new world now awaiting our discovery.

Wisdom of the East has taught that the world we accept as real is but an illusion. Early in this century, this was confirmed by Western science. Sir Arthur Eddington, the great British astrophysicist, wrote in the 20's of his two tables--the illusory table, solid and compact on which he wrote, and the real table of dancing atoms and electron clouds which consisted almost entirely of empty space.

The wisdom of the Dhyani-Buddha, Ratna Sambhava tells that all things are interconnected, the separateness of entities as we perceive them is an illusion, everything is united in a cosmic oneness. Bell's Theorem, dating from 1965, states:

"The statistical predictions of quantum mechanics are definitely incompatible with the existence of an underlying reality whose spatially separated parts are independent. Nature has an element of unity that precludes its being properly represented as a collection of real, localized independent entities (which is exactly how we see it)".

The wisdom of the Dhyani-Buddha, Vajrasattva-Akshobhya tells that all existence derives from ~~there being~~ two levels of representation. Francisco Varella's Calculus of Self Reference, based on Spenser Brown's Laws of Form, demonstrates mathematically the necessity of self-reference for existence.

Eddington stated, ~~that~~ "Undiscriminated sameness and non-existence are indistinguishable". Thus in addition to self-reference, non-sameness is necessary for the perception of existence.

These are but fragments of a map of a new world. ~~Only some~~ But few of the pieces are now in our possession, but ~~enough of them for~~ we ~~us to~~ know that a new reality, a vastly different basic concept of who we are exists ~~out there~~ somewhere beyond the physical and intellectual smog of our time. We have only glimpsed it.

There is an old adage:

If you give a man a fish, you have fed him one meal.
If you teach a man to fish, you have fed him a thousand meals.

But we must go beyond this:

If you reveal to man that there exists a thing called a fish, and that it is good to eat, then, if he is sufficiently hungry, he will search for this thing called fish and discover for himself countless ways to catch them. And this is exactly what the World's great teachers have always done. They did not give us a fish, nor did they teach us how to fish. They only told us that fish exist. They gave us the glimpse, which is A greater gift than either a fish or teaching a way to catch a fish.

The only secret there ever is, is the secret of "it exists" existence. A few years after World War II, Americans were upset when the Soviet Union exploded an atomic bomb. There were investigations and trials, who had told them how to make the bomb. No one did. There was only ~~one secret~~: Such a thing as an atomic bomb exists. And this is why I feel that in spite of all the bleakness, all of the gloom and doom being forecast these days from the rear view mirror, our knowing that there exists a new consciousness, a new reality, and further dimensions to our being, ~~these alone~~ are enough to turn the darkest gloom into the brightest hope.

awk. — a question?

But how do you know this a new consciousness?

We are entering the yearly season of Advent. The time in which we prepare to receive symbolically the Great Gift of the Incarnation. But we are also entering Advent in the seasons of the centuries. We are at a time in human history when we are to prepare to receive a new Incarnation. I think if we would but look up we could even now see the star is already in the sky. Though we, like the Magi, do not know the details, we can see that the event is at hand. The rest is Faith. — how?

If I were to try to describe as best I could what we shall really be doing in the future that is just ahead, I would say:

We shall be journeying together to Bethlehem.

SYSTEMS EPISTEMOLOGY

by

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SYSTEMS EPISTEMOLOGY

The Requirement for a New Epistemology.

The experience of this century has demonstrated in many ways the obsolescence of our ways of filtering and processing knowledge. We nonetheless tend to hold our methods of knowing as basic, unchangeable and absolute-- in somewhat the same way that two centuries ago we endowed Euclidean geometry with absoluteness-- failing to recognize the arbitrariness of some of our epistemological assumptions and values. Specialization and the cellularization of knowledge have generated the requirement for a more comprehensive and integrative approach to our organization of experience to avoid the body of knowledge growing into some new Tower of Babel. Many of the crises we are encountering in the ecology, in population, in resource use and distribution, in human conflict, etc. are now precipitating the recognition that solutions lie beyond politics and jurisprudence. These crises not only have axiological components rooted in historic religious beliefs but also epistemological components rooted in the current world view of Science. Values valid in an age of nomadic migration across the broad plains of an expansive earth--Be fruitful and multiply, Subdue the Earth--are wrong directions for a densely populated finite planet (1). An epistemology that interprets human experience as being an "objective" representation independent of the experiencer is not only delusive but tends to avert considerations of the peculiar powers of the experiencer in interacting with the world. Models and simulations of complex systems, up to the world system, show us that there are failures in our comprehensions.

Complex systems behave "counter-intuitively". Seat of the pants flying does not work for Spaceship Earth. Theobald (2) goes so far as to place the cure for our crises on no less a level than a 'changed way of perceiving reality'. These considerations summarily point toward the timeliness of new value systems, new epistemologies and a new world view.

The current dominant epistemology is the one associated with Science. The precision of definability of this epistemology is not so relevant as its successes in building an extensive and highly reliable fund of knowledge. Though fuzzily formulated this epistemology has been the most successful of all time. However, within the operations of this success intoxicated epistemology there are beginning to be heard some disconcerting signals. The brick by brick edifice of scientific knowledge painstakingly constructed is developing structural cracks suggesting the need for more comprehensive architectural drawings. New fields of inquiry promise severely to stress Science's present frameworks of time, space, form and substance. ESP or Psi phenomena can no longer be denied or ignored in spite of the difficulties of treating them in accordance with scientific validating and falsifying procedures. The ontological dimensions introduced by psychedelic drugs challenge conventional concepts of "reality" and require a new parameterization of our channels of perception (3).

As with all epistemologies, the epistemology of science focuses on what it <u>can</u> do--which is not always the same as what may be important to do. In the present society, good scientists (i.e. successful scientists) are those who work on problems intuited to have a high probability of being solvable. This strategy is certainly appropriate for a young and incompletely tested epistemology. However, in a well established epistemology the displacement of signification-per-importance by signification-per-success imposes biasing restrictions on the directions of inquiry. These restrictions tend to generate a corpus of knowledge that is more likely to map the superficial in the cosmos than the fundamental. The ubiquitous canon, "we should do what we can do", architects distortion and imbalance in epistem, waste and absurdity in praxis.

Science's obsession with "objectivity" seems both futile and pretentious against the backdrop of its opportunistic approach to signification. "Objective knowledge" is the label pasted on the product of the process that begins with human experience, organizes it into a self-consistent structure, then decants the human experiencer. This de-subjectified knowledge after being transmitted and stored by human intellects is applied by human agents to modify the world and its human contents in accord with designs made by human planners. It is not clear why one should seek to remove the sub-system of the experiencer from a world system in order to obtain knowledge of a world system that contains experiencers. It seems rather that the type of knowledge needed for praxis or action must be based on the total system in which the action is to be executed. For example, a science of healing that focuses on the human as object to be healed but ignores the properties of the subjective human as healer will find such phenomena as "faith healing" outside its purview. Such a science must either deny these phenomena or term them "miraculous". There may be nothing miraculous about them at all for a science that studies the world system without excluding the properties brought into it by such higher level sub-systems as humans.

The epistemology of science has had another unsought side effect. It has robbed man of meaning. In the words of Nobel Laureate, Alexis Carrel (4), "Science has made for man a world to which he does not belong". This has been brought about not only through the pursuit of objectivity but through the analytical process of scientific epistemology which is by its nature " a basilisk which kills what it sees and only sees by killing" (5). The atomistic facts that are the excrement of analysis are not the prior-to-analysis holistic system, rich in all of its interior and exterior relationships. We have built a knowledge of the dead pieces devoured and digested by analysis and not a knowledge of the undevoured living world which can never be obtained through this process. Analysis is for the purpose of explanation and explanation is concerned with parts. An explanation is a description of the contents of a system and how it works. Meaning, on the other hand, is a matter of relationships, especially relationship to the context, arrived at through considerations of the whole. It is not surprizing that there is a crisis of meaning in a civilization that is built around an analytic epistemology. It is also not surprizing that our models of the world system are concerned only with the inner workings of the system and rarely, if ever, give thought to the system output. What indeed is the output? What is the function of the world system with its life and intelligence with respect to its total context? Such questions are called "unscientific" and perhaps are properly eschewed by Science since they are intractable in its epistemology. But such questions stand nonetheless as primary driving forces for all human inquiry.

One of the most important sources of the requirement for new epistemologies is the need for the capability to validate and significate all types of human experience. The present epistemology of science has proven its worth for experience that is continuous, ubiquitous and repeatable. It encounters difficulties or an impasse, however, where experience is intermittant, infrequent or where paribus ceteris cannot be invoked. This has resulted in the quality of scientific knowledge being dependent on the subject area of the knowledge. The highest quality knowledge under the epistemology of science centers in those disciplines such as physics, astronomy, etc. where the level of complexity of phenomena is such that repeatability is not obliterated by a profusion of parameters. In general the quality of knowledge decreases as the system complexity increases, reaching a less than satisfactory state in the highly complex behavioral sciences where unique events that are scientifically untractable may carry the greatest significance. For it is not apodictic that the regular and the universal are sufficient to account for the structure and dynamics of the cosmos and its sub-systems. The unique and the exceptional--which for the most part lie beyond the firm grasp of the epistemology of science--may have a significance as great or greater.

The need for epistemologies that will allow us to validate and falsify where samples are small, repeatability not possible, or where unique events overide systems parameters, will not necessarily be met through some single all inclusive epistemology. We should not expect a single epistemology that can equally well subsume sense experience and extra-sensory experience; equally well significate mystical experience and practical planning; equally well validate deterministic systems and normative systems. We should seek to develop critical methods for collecting, testing and signifying appropriate to each type of system experienced, rather than trying to make one shoe fit all feet and judging the quality of the feet by the fit of the shoe.

One of the central concerns of General Systems Theory is with methods and frameworks for the unification of knowledge. There can be no unity of knowledge until there are a) epistemologies suitable for every type of experience and b) a framework --space, time, causal, etc.--of sufficient breadth and depth to permit the formulation of hypotheses and models to account for all the types of experience. A presupposition of Systems Philosophy is that the world is intelligibly ordered as a whole (6). Although the world appears to function as a whole our best representations come out piecemeal. If the world is a whole, there should be some complex multi-level representation possible. The design of such a multi-level construct depends on a methodology for the valid organization of systems into a suprasystem. Whereas the inverse problem of analytical resolution of a system into subsystems is readily treated by such top-down approaches as deduction, and single level systems are amenable through induction or statistical procedures, there is no corresponding technique for vertical bottom-up organization. This lacuna is a task for new epistemologies.

Further epistemological requirements are generated by another concern of General Systems Theory. This is to derive and validate the basic principles and meta-principles that commonly govern physical, bio, socio, eco and artificial systems. This task has a resemblance to the epistemological step taken by the Greeks on a more elemental level when they were able to replace such statements as $3^2 + 4^2 = 5^2$ and $5^2 + 12^2 = 13^2$ with the meta-statement $a^2 + b^2 = c^2$, valid for all right triangles. But before this could be done the validating process of deductive proof had to be perfected and incorporated into their epistemology. The General System theorist of today faces a similar epistemological task in the development of suitable canons for validifying and falsifying meta-statements concerning systems behavior. There are, for example, analogies between linguistic and biological evolution, between the evolution of organisms and of artifacts; there are Zipf's relations (7) between rank and population for cities, or rank and frequency for words in manuscripts and similar rank-frequency relations in many diverse systems; there is the two-third power law relating the sizes of external and internal components of organizations analogous to the surface area and volume of the interior of metric solids (8). What kind of "$a^2 + b^2 = c^2$" meta-statements can be made in these cases and what level of validity for such meta-statements can be established? In other words, is there a General Systems Theory?

Systems may operate in one or more of three dynamic modes: deterministic, telic (or normative), and probabilistic. In the past it has been customary to argue which of these three modes exclusively governs the dynamics of the world system. Today we are finding it more useful to postulate the co-existence of all three and forego the futility of trying to reduce any two to the third. However various sectors of the intellectual community still prefer to assume the exclusiveness of one mode for their own purposes. Macro-physical scientists tend to assume the deterministic mode applies exclusively in their systems;

micro-physical scientists, the probalistic mode; and social scientists, the normative mode. This places the subject area of the bio-scientists at the level where modes interface. If biologists opt for an exclusive mode (as most do) they encounter the lacunae of reductionism or those of vitalism. If they opt against exclusiveness they encounter the epistemological problems of interfaces. In general terms, the modes may be discriminated by some first order attributes: Deterministic systems are closed-ended, causalistic, reversible, predictable and receive their inputs on the operational (energy) level. Normative systems are open-ended, finalistic, irreversible, forecastable and receive their inputs at various control (informational) levels. Probabilistic systems are locally open-ended, generally acausalistic, irreversible, unpredictable and appear to generate their inputs autonomously. (Ensembles of probabilistic systems, on the other hand, are closed-ended, irreversible and forecastable.) Since General Systems Theory is concerned with all species of systems, the nature of these modes and their interfaces (or, it must be allowed, their possible reducibility to one another) constitute a central task for general systems research.

First are the difficulties with the view of time employed by Science. It is no longer expedient to ignore the finalistic--future influencing the present--aspects of normative systems simply because they cannot be subsumed in the historical notion of time developed in accordance with the causality principle operating in deterministic systems. The bio and social sciences have had to build their models around too narrow a notion of time. Whether or not such difficulties as are implicit in the reductionism vis-a-vis vitalism impasse could be resolved by a more comprehensive view of time cannot be claimed. But General Systems Theory should recognize that departures from the "strict constructionalism" in certain frameworks of Science--such as time-- are necessary if we are to develop the new epistemologies needed for processing and synthesizing all human experience.

Second is the matter of values and value systems. Normative systems in being open-ended are directable through choices made among a set of images of the future. Choices in turn are narrowed by decision algorithms which include in their steps the application of values and value systems. Science prides itself on being value free. This (without the pride) is an overt admission of its inability to cope with normative systems. But this inability derives, as we have seen, as much from the limitations of its notion of time as from Science's epistemological value of objectivity. The resulting exclusion of investigations by Science into values and value systems has created a critical shortage in our body of knowledge, with derivative malnutritional maladies in our bodies politic.

Related to normative or telic systems is the subject of telos itself. The properties of telos--purposful or finalistic behavior--have not been adequately investigated. We do not know, for example, the level of complexity at which telos first appears within a system (or whether telos is ever <u>within</u> a system but always must bear a contextual relationship). Nor do we know the relation between telos and consciousness or between telos and life. Telos may be an essential concomitant of life appearing on the systems scala at lower levels than consciousness. Or all three may occur in various orders at various levels of the system scala depending on time and other systems parameters.

The foregoing considerations:

> Our axiologically and epistemologically rooted crises; the traps of objectivity; the denial or de-signification of areas of experience that are not amenable to an epistemology designed for the repeatable and the ubiquitous; signification per self directing successes; the absence of holistic and contextual considerations with the consequent desication of meaning; the exclusion of normative systems together with their concomitants of values, value systems and telos; the need for ways of validating and falsifying the propositions of General Systems Theory; the need for unitary frameworks of space, time, structure, etc. and for techniques of synthesizing that will permit the unification of knowledge.

These, individually and summarily, create the requirement for new epistemologies and frameworks. This requirement broadens the traditional concept of an epistemology. No longer is epistemological concern limited to what knowledge is and the ways of knowing. It must consider the entire "knowledge system", i.e. the collection, filtering, organization, testing, interpretation, evaluation, recording and transmission of experience. It must consider the nature of the growth of the corpus of knowledge and the various feedbacks that the existing corpus inputs to the growth process. It must consider the morphology of inquiring systems. In all of this General Systems Theory not only has basic requirements for new epistemologies and new frameworks, it also has basic contributions to make toward meeting these requirements. The general systems approach appears to provide the best conceptual point of departure for researching the knowledge system. Only a comprehensive open-minded, yet critical, view such as that taken by General Systems Theory will suffice for realizing the epistemological requirements that have been outlined here. The assumptions and aims of General Systems Theory are facilitating to the structuring of suitable epistemologies for many areas of experience and for organizing them into a unitary framework. The close parallel between these epistemological tasks and the aims of General Systems Theory makes it appropriate to introduce the term "Systems Epistemology" for this systems oriented study of the knowledge system. We shall use this term with this meaning in the following sections.

The Characterization Of Epistemologies.

The knowledge system bears the same relation to human society that the genetic code bears to human life. Epistems are genotypes, praxes are phenotypes. Innovation takes place in genotypes, testing in phenotypes. The requirement for a new epistemology is thus no less than a call for a genotypic modification, an altering of the knowledge system's genetic code. Genotypic modifications, whether biological or epistemological, are challenges of the highest order. The analogies between the two systems should prove to be mutually helpful to the bio-geneticist and the systems-philosopher in examining the aims and the consequences of their parallel tasks in "code modification".

We may take a second analogy to further illustrate the systems nature of epistemology. The basic components of an epistemology are a community of experiencers, a set of ways of experiencing and an aggregate of experiences or things experienced. We may think of the sources of the experiences as transmitters, some of which most experienciers or receivers can tune in, while some are available only to a few receivers at irregular intervals. In this metaphor the various senses (physical and other) are the communication channels and the experiences are the messages received. (It should be pointed out that we deal only with the messages and not with the transmitters. The "true nature" of the transmitters, i.e. the nature of "reality" is an ontological not an epistemological question which is not relevant here.) Knowledge is the organization that the community of experiencers places on the representations of selected sub-sets of their experiences. An epistemology consists of both the <u>imposed</u> and <u>adopted</u> rules employed by the community of experiencers for the collection, representation, filtering, organization, evaluation and application of their experiences. The term "community" implies that the experiencers share, at least in part, the ways of experiencing and, at least in part, the same experiences. This further implies that the members of the community each possess a copy of the <u>code book</u> that allows them to communicate with each other the encoded representations of their experiences. The <u>imposed</u> rules are the constraints that limit the experiencers in their ways of experiencing and in bringing to consciousness their experiences, i.e. in our metaphor, the basic frequencies and band passes of the channels and the sensitivities of the receivers. The <u>adopted</u> rules are the conventions agreed upon by the experiencers for the processing of their experiences. Different epistemologies may be parameterized in part by their adopted rules for validation, signification, etc. These rules, in turn, depend on the relative emphasis placed on certain <u>epistemological values</u> such as objectivity, consistency, elegance, etc.

Epistemologies may also be characterized in terms of their "volumes" in three types of space: an experience space, a model (or construct) space, and a cultural space. The dimensions in the experience space correspond to such parameters as the number and properties of the channels through which the experiencer receives his experience, (such as the sense channels); the nature of the signals coming over the channels, such as their intensity, frequency of occurence,, duration and continuity. The properties of the experience space are generally fixed and correspond to the imposed rules governing the epistemology. However through the development of sensory extension instruments such as telescopes, thermocouples and spark chambers and through the development of consciousness extending techniques such as bio-feedback displays, psychedelic drugs and meditative disciplines, the volume in experience space,which is a measure of the experiencable domain of the phenomenological world, may be enlarged.

The model space usually has three dimensions corresponding to the three basic epistemological values of comprehensiveness, precision and simplicity. The volume in a model space measures the epistemological utility of a model, theory or explanation (9). The larger the domain of experience over which the model is valid, the more precisely it maps experience and the simpler or more economical it is, the higher its overall value. However, there are some trade-offs between these three values. Precision frequently must be bought at the expense of simplicity and field of view (comprehensiveness) traded for resolving power (precision).

The third space, a cultural or societal space, has to do with the social acceptability of an epistemology. Its dimensions are the length of time the epistemology has been culturally established, the number of people (weighted by their social importance) who subscribe to it, and its successfulness as measured by its ability to meet certain cultural values such as utility. (Successes are also functions of the volumes in model space.)

From these characterizations we see that in both model space and cultural space there are components of the knowledge system that contain values. The knowledge system is thus in part a normative system involving choices that establish these values, a fact contradicting any pretentions to absoluteness for an epistemology. The shape of the corpus of knowledge results from the imprints of these values, giving us the strategy of "value-perturbation" as a way to detect unsuspected adopted filters that limit our experience. Different epistemologies not only focus on different regions of experience space but tend to adopt different values for their model and cultural spaces. For example, the epistemology of Science and the epistemology that the Greeks called "doxa" and we call common sense are both primarily concerned with the same experience space--that of the physical senses. (Science, however, is more deeply involved with instrumental extensions of sensory experience space.) These two epistemologies differ in their model spaces primarily through Science's much greater emphasis on precision and less concern with simplicity. The two differ in their cultural spaces primarily through Science's emphasis on success and doxa's emphasis on body counts. Only in Science and in certain axiomatic epistems such as mathematics are there highly formalized validating procedures. Doxa validates through "workability", which as time passes drifts toward validation through tradition or the validation through the authority of body counts. The epistemologies used by various "occult" disciplines usually validate directly through the authority of some individual or text. It must be noted, however, that validation by authority is not entirely absent from science.

Authority in Science, however, operates not on the level of fact validation, but on the level of prescription and proscription of methodology. For example, in the so-called Velikovsky Affair (10), Velikovski's facts turned out to be correct but they were opposed because they were obtained by using a methodology unacceptable to Science.

Mystical and religious experiences possess no formal epistemologies or validating procedures. The nature of their experiences tends to be highly personal and oftimes much of it is not communicable. Such experience obviously cannot be passed through the filters of repeatability and ubiquity that are imposed rules of epistemologies that are based on the least common denominator of general communicability, as are both Science and doxa. The basis for validation in these areas of experience, when it is not some authority, is an "inner-recognition". Inner-recognition is a "gut-level" ultimate in the act of knowing-- a sort of resonance with what is true. It underlies the criteria by which we are guided in the construction and testing of our formal epistemologies. It is the court of last and highest appeal, transcending pragmatic criteria which are always associated with an interval of time in their propositions of validity. It is important, however, to discriminate inner-recognition from the "hunches" and "feelings" and other gestalt perceptions that we lump all together in the English language under the term <u>intuition</u>. Inner-recognition and gestalt sense perceptions belong to different levels of intuition. These levels constitute an important sector of study for new epistemologies.

We have noted in the case of doxa the tendency for success to lead to the establishment of the authority of tradition. This is an evolutionary tendency in all epistemologies, perhaps the basic dynamic of the cultural space. But authority on whatever level, once established, diminishes the frequency of appeal to either pragmatic tests or inner-recognition. These important feedback loops in the knowledge system tend to atrophy under the warm glow of past success. An epistemology is one system that cannot afford to be governed by the popular adage, "If you find something that works, stick to it". Vital and effective epistemologies have no orthodoxies, they must be periodically reviewed and renewed on every level.

Approaches to a Systems Epistemology.

How do we begin to meet the requirements for a unifying meta-epistemology that will enable us to build a knowledge system,containing the essential features of "genetic tapes",and going beyond, provides a suitable "cultural tape". It is not easy to modify epistemological patterns of thought and practice that have become so ingrained as to be invisible to us. The evolution of these patterns has been slow and painstaking, requiring generations for experiential feedback to effect changes. Now we are asking for a new epistemology to be designed in years not generations. Such a meta-revolution feels subversive on everybody's list. Clearly this is not a task for any one group or school of thought. It can only result from the integration of many ideas and approaches. Four essential steps appear to be involved:

1) Development of awareness of the need for a Systems Epistemology.
2) Critiquing existing epistemologies and epistems to find a fundamental parameterization of the knowledge system.

3) Utilizing this parameterization to generate a morphology of alternative sub-systems to function within the knowledge system.

4) Evaluate and select suitable sub-systems. Integrate these into a Systems Epistemology.

The first section of this paper contained some remarks applicable to step one. The second section sketched a few ways of looking at epistemologies relevant to step two. Since steps 3) and 4) depend on the completion of step 2), we can go no further at this time. The remainder of the paper will discuss a few epistemological miscellany useful as "Hilfsmittel" in the various steps.

Matters of attitude are among the prerequisites for a Systems Epistemology. One important attitudinal problem is how to achieve an effective blend of openness and criticalness. Openness is frequently threatening because it might expose work involving a considerable investment of time and effort to inputs that would invalidate it. The response to this threat from openness is oftimes to employ criticism as a wall to shut out innovative inputs rather than as a tool to evaluate them. Proper criticism, however, is based on consciousness of where we are and what we are trying to do and this consciousness does not fear openness, fuzziness or the tension of deferred validations.

A useful approach that effectively combines openness and criticalness has been described in the rubrics of Zwicky's Methodology of Morphological Construction (11), a methodology useful for syntheses. In Zwicky's technique one employs a temporal pattern of alternating expansion and contraction: An expansive phase of unencumbered imagination of possibilities followed by a contractive phase of critical evaluation and decision among these candidate possibilities. The alternating pattern in time is the essential feature. It is defeating if the imaging and the critiquing phases are not kept scrupulously distinct. Without a season of freedom from criticalness the full powers of the human imagination cannot be released for giving birth to innovations; without a season of focus on criticism, free from the disruptions of novae, no model can be built. Without the temporal pattern of alternating openness and criticalness there could not be the temporal pattern of innovation and construction, innovation and correction on which the growth of the corpus of knowledge depends. Otherwise all would remain either permanently fluid and nebulous or permanently rigid and ossified.

The ability to employ such an alternating pattern depends on an attitude that can withstand the tensions of postponed resolution of antithetical concepts, (admittedly a difficult stance for the "now generation"). Resolution and decision are required for praxis not for epistem. Action and implementation demand the convergence of option space; but it is otherwise profitable to keep the stock of possible alternatives as rich as possible for as long as possible. One of the longest unresolved tensions in the history of science had one of the most fruitful resolutions, when finally it came. This was the particle-wave tension and its subsequent resolution through the quantum mechanics. Had not Huygens' wave model possessed such a broad experiential base, it is possible that certain of Newton's followers using their customary Cromwellian clout would have succeeded in resolving the particl-wave question in the 17th century in the usual manner through repression. However the co-survival of the two antithetical viewpoints provided a stimulating and fruitful tension within physics that delayed resolution until it could be made through synthesizing rather than through opting. Alternative models and perspectives are useful even when their claims for adoption are not so nearly equal as in the wave-particle case. Alternatives oftimes provide us with stereo vision.

Postponed resolution of epistemic tensions would have an important effect on the manner of growth of the corpus of knowledge. The present manner of knowledge growth resembles that of crystal growth. Both grow through a process of epitactic accretion to the outer surfaces of the existing bodies. In epistemology explanation of the new is always in reference to the terra cognita of the well established corpus. In fact "to explain" generally means to relate to the familiar. The custom of insisting on this one restrictive type of relation -- linking new discovery to the main corpus -- results in the restriction of growth to epitaxis on a single continent of knowledge. In this process the "islands of knowledge" that cannot immediately be related to the main body have small chance of survival. Only when an island provides some compelling utility or economy can it survive without being explained. For example, Heaviside's operational calculus was too useful to discard even through it could not immediately be validated. The Titius-Bode Law of planetary distances has survived over a century without explanation because it discloses an intriguing simplicity of organization. But the general rule for new experience is "be explained or perish". If the tension of unexplainable islands could be sustained then epistemic growth could proceed through the growth of each island and whenever possible through the relating of islands to one another without the necessity of their being related to the continental corpus, i.e., of being explained. A current example of an island of knowledge is the UFO phenomenon.(12) The non-epitactic approach to UFO's would be to postpone explanation in terms of psychology, extraterrestrials, or whatever, and synthesize the various patterns contained in the observations; then utilize the patterns to provide the specifications for the design of a "flying saucer" going as far as is possible by employing known relations and in this way isolate the lacunae in our knowledge. These lacunae will probably provide the keys for a future explanation. But since UFO's cannot now be explained, the epitactic process chooses either to dismiss or supress the subject instead of encouraging the island to grow. In this case trouble was even taken to establish a hierarchy of committees to validate the suppression.

The basic question regarding islands is not explanation, it is authentication. To authenticate a body of experience usually means to establish the existence of a non-illusory, non-chance, internally consistent set of events. In a systems epistemology that must treat with the roles of both illusion and chance, authentication is better defined more generally in terms of the existence of some critical size for relational patterns whether or not illusion and chance be present. The epitactic approach, in focusing on the features that relate new experience to the main body of knowledge, gives a preferential status for purposes of explanation to those systems that, for whatever historical reason, happen to have been examined first. Since the first systems to be successfully studied scientifically were those lowest on the systems scala -- physical and chemical -- explanation for new experience must be made in terms of these systems. Thus reductionism is an imperative of an epitactic epistemology. If other systems than chemistry and physics had had this primacy of study they would also have had primacy for a role in explanation.

When Apollo 8 brought back the first pictures of the blue globe of Earth floating in space, we received a new paradigm for our epistemologies. Instead of viewing structures as being based and dependent on some main body that is foundational for all components, we now can see that a foundation is but one more synapse in the structure, and like all the other links and synapses, it too floats. Relational links of every sort between synaptic islands are para-explanations. Our epistemic structures will be richer and more comprehensive in so far as we allow the great variety of linkages that may exist between various islands to enter, whether or not these linkages exist between each island the the primary corpus. This is, in the language of systems commonalities, the basic aim of General Systems Theory.

In summary, the requirement for new epistemologies is primarily to supplement the epistemology of science. The past successes of Science have encouraged us to endow it with the future promise of unlimited success in solving all problems and leading us to the realization of whatever goals we seek. But this is unfair to Science. Those working closely in and with science do not make such claims nor encourage such expectations. In fact, the more closely one works with the epistemology of science the more clearly one sees its limitations -- limitations of the sort pointed out in the first section of the present paper. However, the call for new and supplementary epistemologies is not likely to be heeded in face of the myriad successes of Science. But success does not get corrected and we may expect that the destiny of Science is to experience the "failure of too much success". Before this happens those concerned with preserving whatever positive has been achieved in the cultural tape must begin to make the needed corrections and to broaden the base for the critical acquisition and evaluation of knowledge of whatever nature; new epistemologies, one appropriate for each domain of inquiry, must be structured; and the whole unified under a comprehensive framework that permits experience of every sort to be modeled. This set of new epistemologies, together with that of science, and the coordinating framework for their synthesis is what we seek here under the designation, Systems Epistemology.

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EVALUATION TECHNOLOGY: THE APPLICATION OF DECISION AND UTILITY THEORY TO PLANNING, OPERATING AND MANAGING COMPLEX SYSTEMS

TECHNOLOGICAL FORECASTING SUMMARY

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PRESENTED BY

CONTINUING EDUCATION IN ENGINEERING AND SCIENCE
UNIVERSITY EXTENSION, UCLA

TECHNOLOGICAL FORECASTING GLOSSARY

<u>FUTURISM</u>: The philosophy that the future is continually defined and shaped by human imagination, choice, and planning rather than being deterministically governed by the past. Orientation toward anticipatory thinking and action based on foreçasting and long range planning. The sociological phenomenon of concern with the future resulting in a professionalism and institutionism for guiding change.

<u>FUTURISTICS</u>: The study of the probabilities and implications of alternative conceivable and possible futures. Specific images and scenarios of future possibilities, specific forecasts, assessments, and plans. The practice of any activity that generates images of the future, predicts or shapes the future.

<u>FUTUROLOGY</u>: The subject of how the future is studied. The dynamics of technological and social change; the roles of causality, finality, determinism, volition, and chance in the processes of change; the nature of time, the modeling of change; the design of methodologies for forecasting, imagining, assessing, and planning alternative futures.

<u>FORECAST</u>: A relatively high confidence level probabilistic statement concerning the future. Three basic types are common:

> <u>Extrapolative</u>: A forecast of the most probable future based on the unmodified continuation of existing trends.
>
> <u>Exploratory</u>: Forecasts of probable futures resulting from specified sets of alterations in existing trends.
>
> <u>Normative</u>: Forecasts of probable futures derived in accordance with alterations in existing trends as effected by specified goals.

<u>PLAN</u>: A detailed and systematic formulation of a set of objectives together with a description of procedures and schedules for their realization.

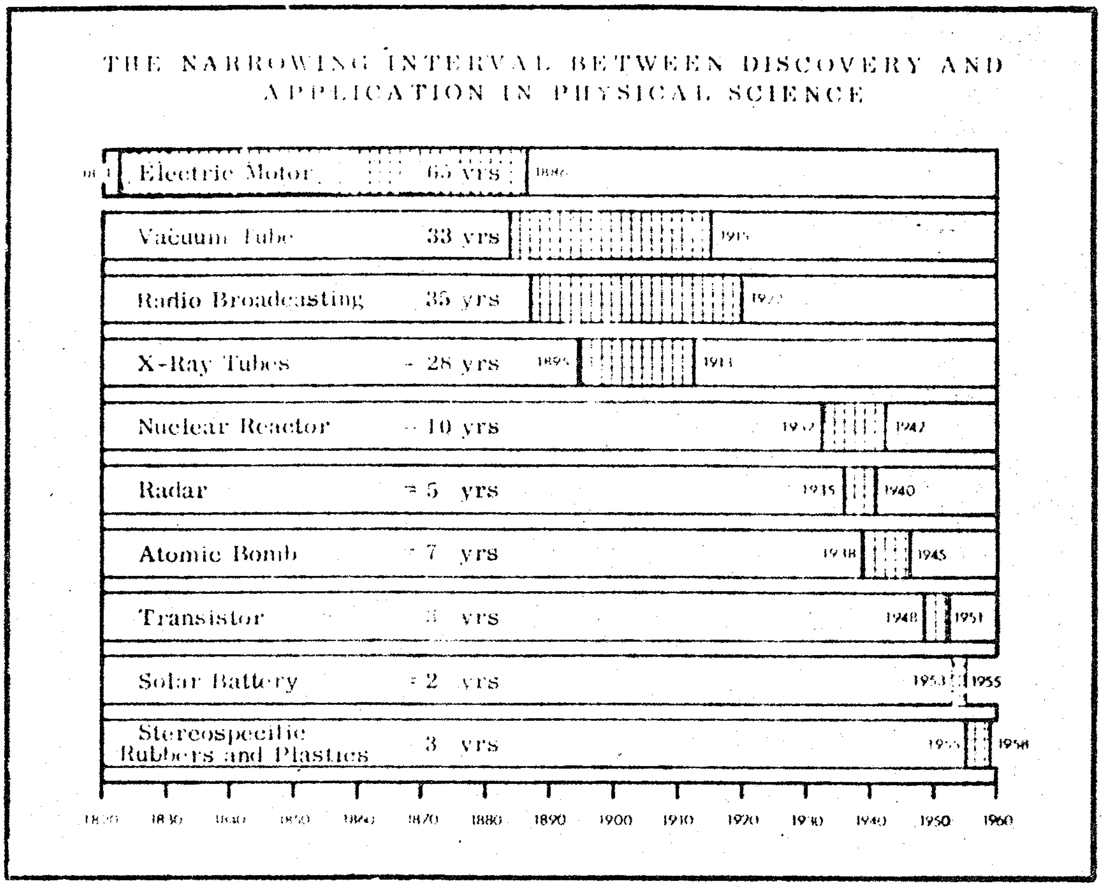
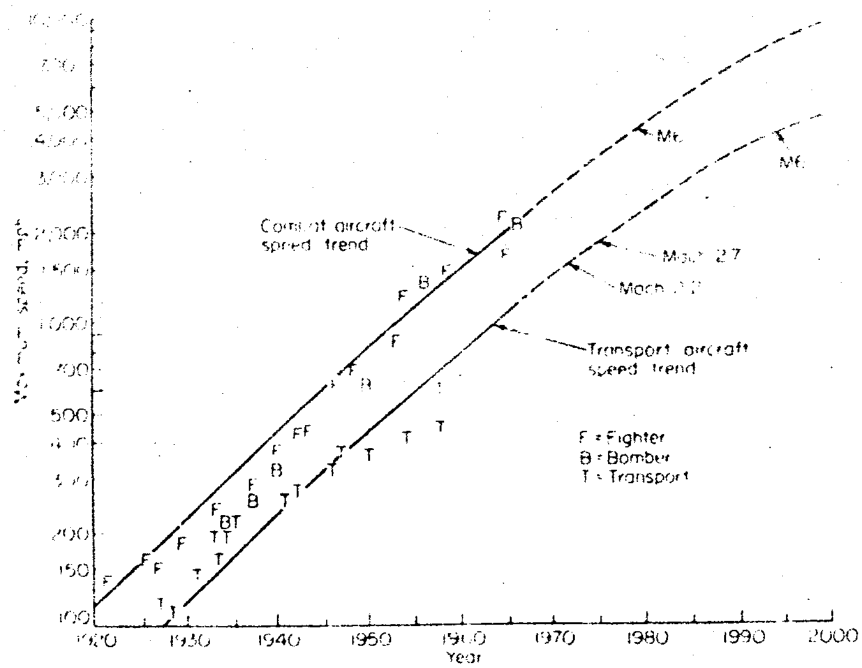


Figure 1 (Reference 4, p.60)



Speed trends of combat aircraft versus speed trends of transport aircraft, showing lead trend effect.

Figure 2 (Reference 5, p.119)

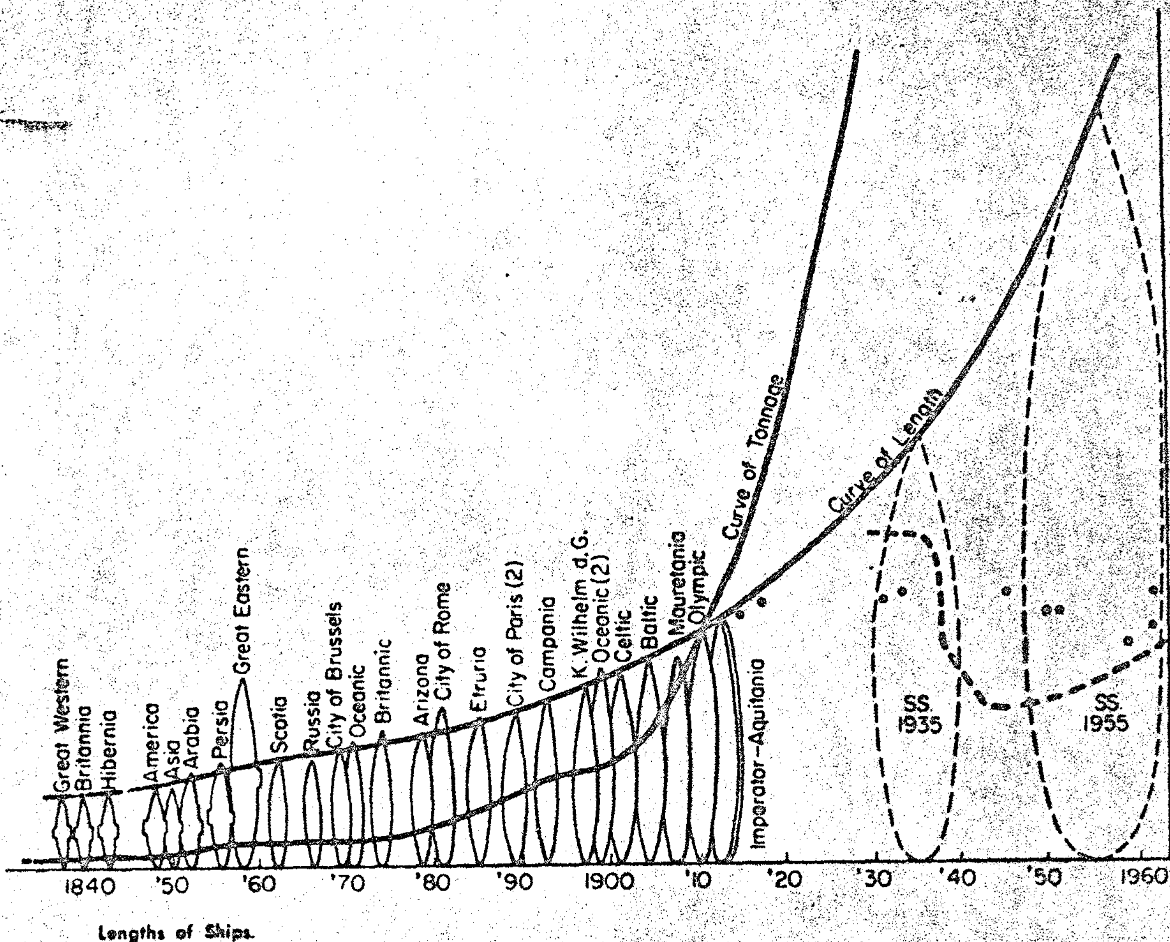
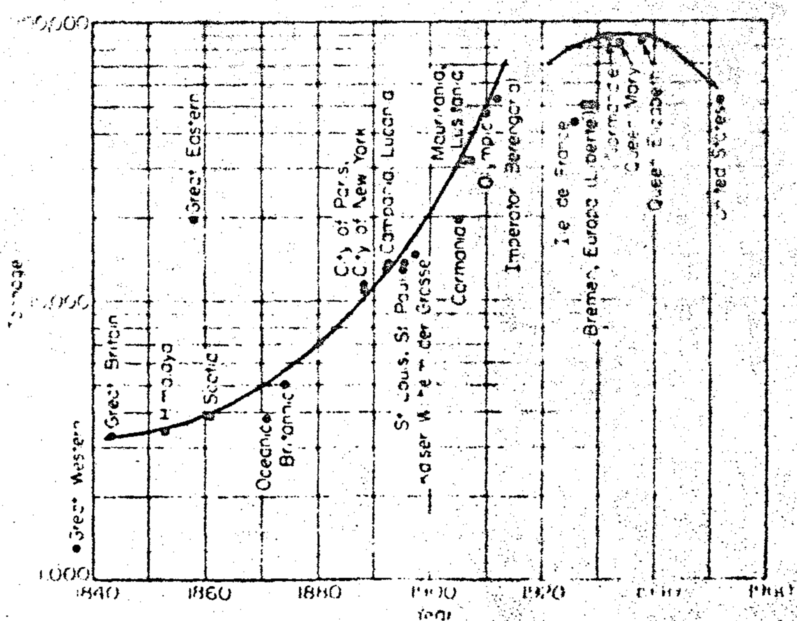
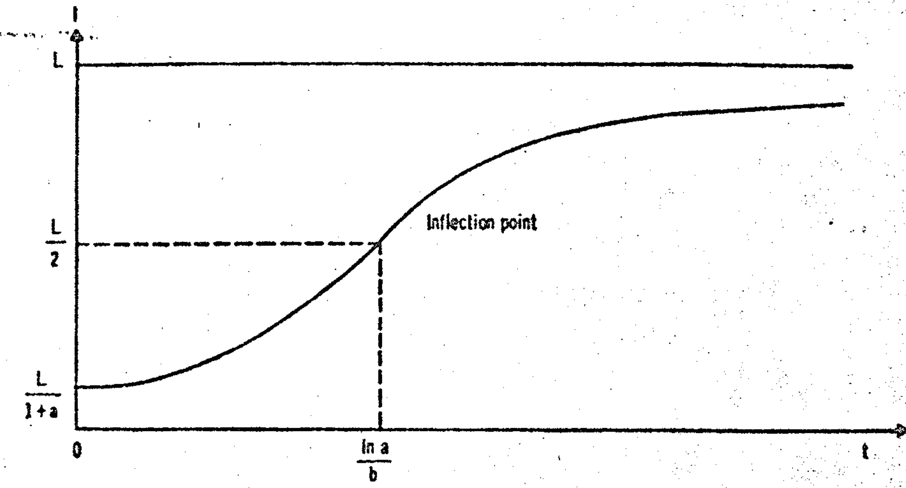


Figure 3 (Reference 17, p.22)



Ocean liner tonnage.

Figure 4 (Reference 5, p.25)



$$I = \frac{L}{1 + ae^{-bt}}$$

I = Accumulated information (state of knowledge) at time t.
L = Upper limit of information (due to constraints).
t = Time.
a = Constant, dimensionless.
b = Constant, per time unit.

Figure 5 (Reference 1, p.151)

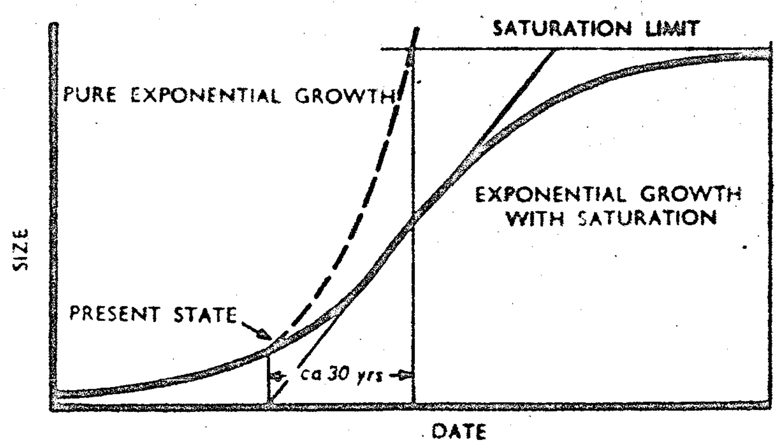


Figure 6 (Reference 39, p.401)

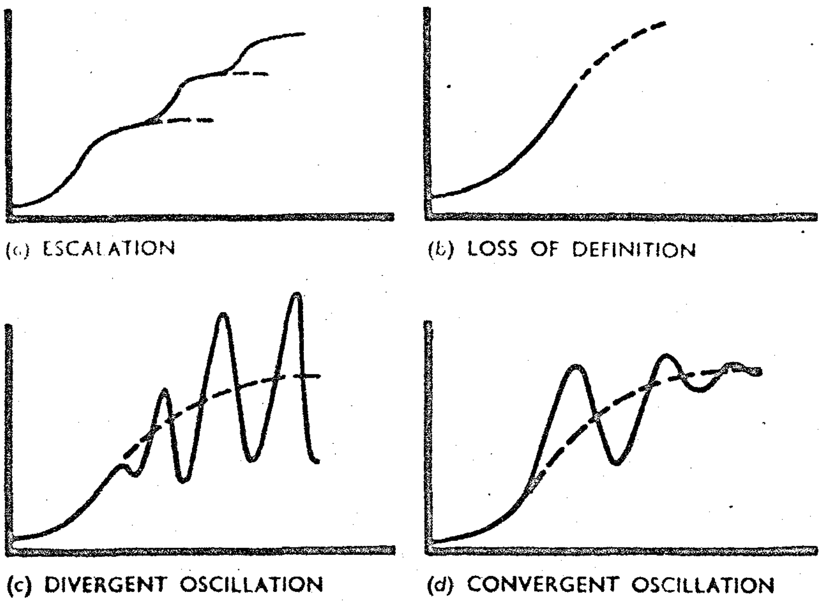


Figure 7 (Reference 39, p.381)

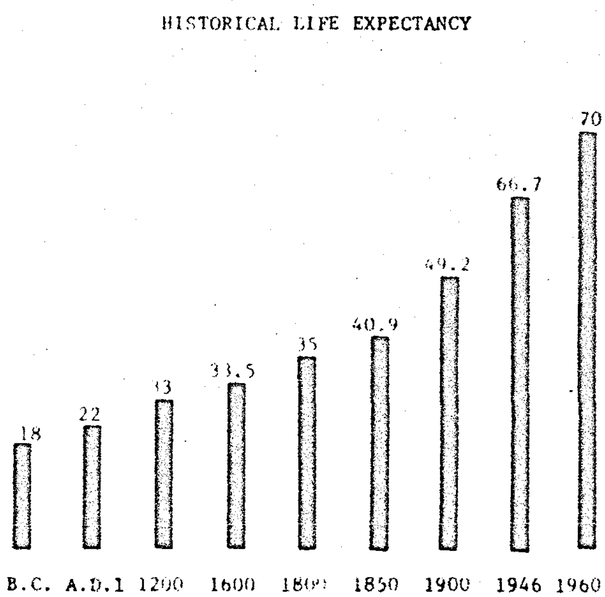


Figure 8 (Reference 4, p.85)

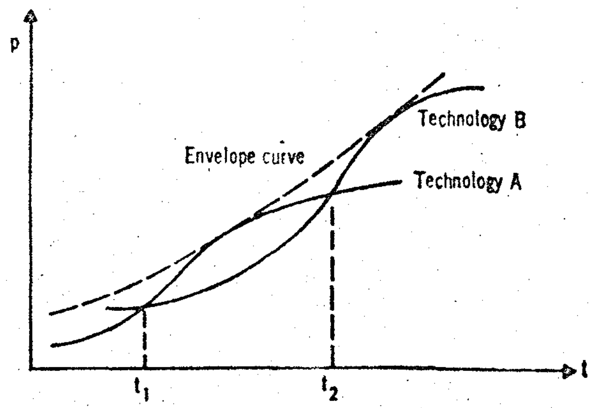
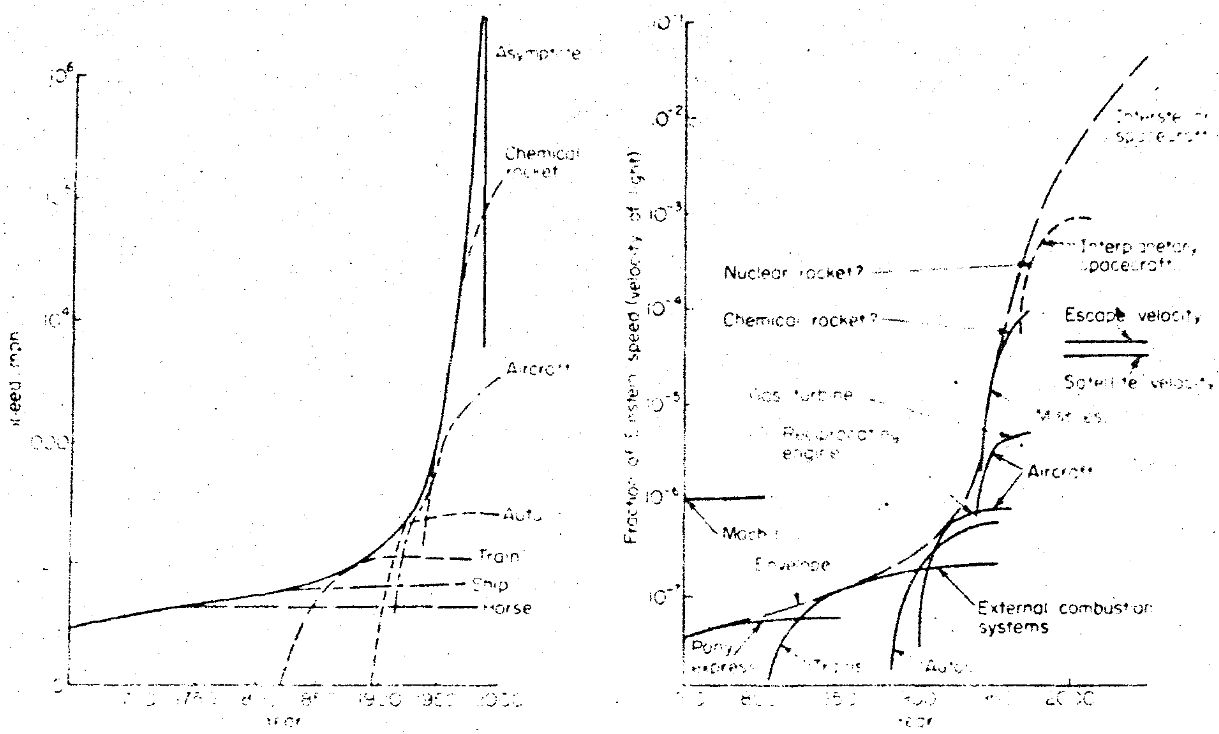


Figure 9 (Reference 1, p.165)



Speed trend curve. *Speed trend curve.*

The same parameter is plotted in both graphs. The one on the left is extremely misleading because an inappropriate scale is used.

Figure 10 (Reference 5, p.21)

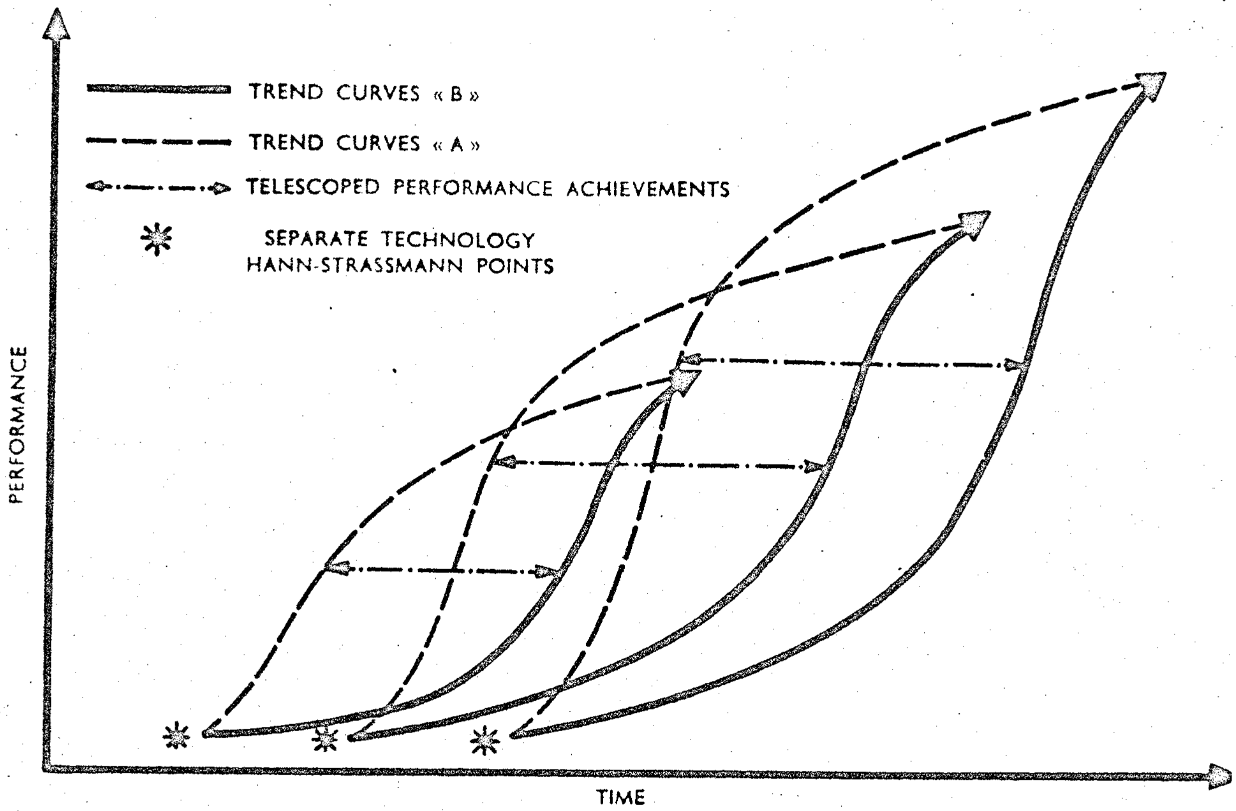


Figure 11 (Reference 39, p.502)

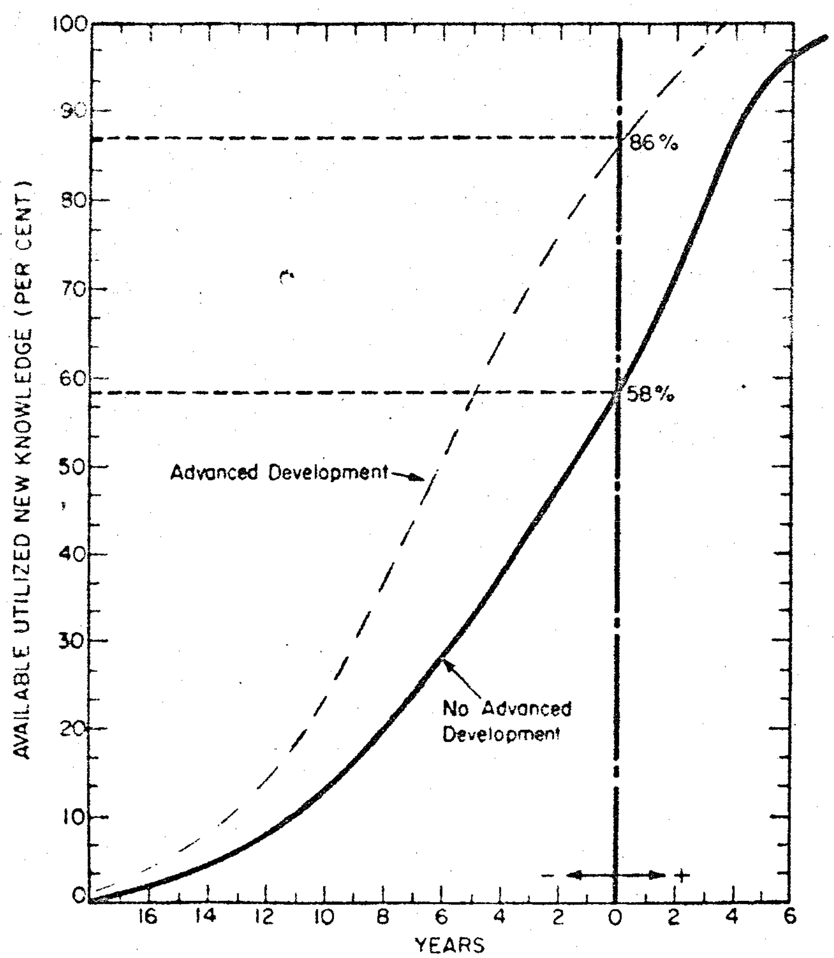


Figure 12 (Reference 17, p.43)

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Summary of

ALTERNATE DYNAMICS IN NORMATIVE SYSTEMS

by

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ALTERNATE DYNAMICS IN NORMATIVE SYSTEMS

Summary

The formulation of a branch of behavioral science to which the name "Paradigmatology" has been given, derives from the recognition of the importance of the role of paradigms, ~~i.e.~~ worldviews, core beliefs or metaphysical constructs~~,~~ in the shaping of human behavior. Humans operate through and with images, be they Weltanschauungs or merely metaphors. Images energize us, provide us with personal and cultural orientation, underlie ~~what~~ those things we consider interesting and important, help formulate our values and define ~~our notion~~ what we choose to call ~~notions of~~ success. They enlist our dedications and frequently even command our continuing allegiance in the face of coercive stimuli for their abandonment. It is not surprising that no purely stimulus-response psychological theory provides an adequate base for understanding the behavioral patterns of an imaging species. Whenever images intervene between the stimulus and the response, diverse and frequently unexpected responses come from the same stimulus. The importance of the role of images in human behavior has been underplayed. The new field of paradigmatology is addressing a neglected but very important sector of behavioral science.

Paradigms are not universally shared. They vary not only from culture to culture but from age to age. Maruyama (1) has shown how misunderstandings arise between cultures (or even sub-cultures) from the differences in the paradigms adopted by the cultures. Paradigmatic differences oftimes lead to projections of irrationality or deceit onto members of the other culture. Examples have been cited where paradigmatic differences have lead to suspicion and

distrust, to hostility and conflict. Paradigmatology may be seen in the perspective of communication theory as the study of the problem of how to assure that the sender and the receiver have the same code book.

But misunderstandings may arise even between those who possess identical code books. An important parameter in paradigmatology concerns the differences in interpretation of a paradigm that arise from differences of psychological type. C. G. Jung has identified four fundamental psychological functions: thinking, feeling, sensation and intuition. Four corresponding psychological types derive from the relative development of these functions within the individual. For example, a sensation type is a person in whom the sensation function is especially well developed and the other three functions are relatively underdeveloped. Basic differences in the way each psychological type experiences and interprets experience result in a single Weltanschauung or paradigm operating in practice as four separate paradigms. Many of the same difficulties of communication encountered between those subscribing to different paradigms are also encountered in communication between persons of different psychological type who profess the same paradigm. The projections of duplicity or irrationality ~~arising~~ that arise from misunderstandings between types are placed on individuals rather than on cultures or minorities. Psychological types may be said to constitute a built-in paradigmatic difference within every culture and group.

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The importance of Jung's psychological types lies not only in the insights afforded into individual behavioral differences but in the illumination they give to the basis of social organization. Four elemental cybernetic or control sectors are found almost universally in human societies. These can be identified by the categories: Prince, Warrior, Priest and Judge; and in a highly developed society are recognizable in the sectors charged with administration, defense, knowledge and correction. The necessity of this fourfold organization for the proper functioning of a society can be seen in groupings as elemental as that of a hunting party of Kalahiri Bushmen whose membership consists of a headman, hunter, shaman and clown (2). Similar four-fold social organization is found manifested in the architecture of the Yucatecan ritual center at Uxmal(3), in the social traditions of the North American Plains Indians (4) and in the caste systems of India. Thompson (5) has displayed a mapping between these four cybernetic functional sectors common to social organizations and the Jungian psychological Paramity ~~types~~. Although no causalistic model demonstrating a necessary isomorphism between the psychological structure of individuals and the structure of their societies can be claimed, the reflection in social organization of the psychological patterns identified in individual humans, like the reflection of the structure of a molecule in the shape of a crystal, is an expected rather than an anomolous development from a general systems point of view. Our social organizations develop these functions because our psychic natures require them.

The existence of a mapping between psychological types and cybernetic sectors supports the fact that Politics, Defense, the Judiciary and Academia ~~each~~ all interpret a paradigm in such a way that it appears each is professing a different paradigm. Misunderstandings between the sectors invariably arise. But since it is essential that they continue to work together, each develops a mode of intercourse operating under Maruyama's principle of dimensional reduction (6). Privately each sector develops a somewhat disdainful attitude toward the others, reinforced by the consciousness of its own superiority in the one really important function--the one that it performs best.

The purpose of this paper is to establish the relations between types and sectors, exploring their corresponding strengths and weaknesses. Typical perceptions, motivations and responses of each psychological type are used to classify the various dynamics and approaches to change that obtain in social systems.

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ALTERNATE DYNAMICS OF NORMATIVE SYSTEMS

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Four basic informational functions are common to all control systems from simple thermostats to corporate headquarters. On the system level of the individual human, these system information functions correspond to the four psychological functions formulated by C. G. Jung in his researches on psychological types. On the social level the functions correspond to the four governing and professional categories found almost universally in both primitive and advanced cultures. Following Jung's typing of individuals according to the relative development of the functions in their personality, cultures may be typed according to the relative emphasis of the four functions within their social structures. Four basic types of social dynamic are identified that are useful in characterizing organizations and societies.

The plan followed in ~~the~~ this paper is to develop the fundamental functions from the properties of elemental control systems, then to examine the forms that the functions assume in more complex systems. [1]* The principal focus of ~~the~~ this paper is on the attributes of the functions as they operate in individuals and social organizations, which is to say in <u>normative systems</u>, or those systems that possess a continuum of stable states corresponding to the spectrum of human norms and goals. The principal results of ~~the~~ this paper lie in the homologies, or correspondences between part-to-whole-relations, found to exist between psychological and social functions. These homologies are of general interest in that they show the four functions constitute a meaningful integrative schema of wide applicability, which provides insights into the nature of man and the structure of systems on all levels.

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* Numbers refer to notes and references at the end of ~~the~~ this paper.

The Four System Functions

The study of physical systems in the eighteenth and nineteenth centuries provided us with basic concepts such as energy, entropy and probability that have proved to be powerful tools for formulating and solving technical problems. The study of control systems in the twentieth century through the development of concepts such as information, feedback and programming is furnishing us with tools that are helping to formulate and solve problems associated with higher order systems including biological and social systems. One system concept that is important throughout behavioral and systems sciences is that of function. This is a word used with several meanings, but in the general systems sense used here, a function will be defined as a set of one or more elemental operations that is performed repeatedly in the same manner in order to enable the system to fulfill its tasks or purposes. The tasks or purposes of the system may themselves be functions when the system is regarded as imbedded in a larger system. In this paper we shall be concerned primarily with control systems, which means that the sets of operations that make up the functions are operations on and with information. Some typical elemental informational operations are filtering, storing and replicating information, or they are arithmetic and logic operations such as comparing and grouping data.

As a specific example, let us consider one of the simplest control systems, the ordinary thermostat, whose purpose is to hold the temperature of a room as close as possible to some pre-selected value through the control of heating and cooling devices. Ordinarily such a system is studied from the point of view of negative feedback operations, but here we shall look at it in terms of three basic functions: First, the thermostat must perform that function or set of operations that allows it to measure the room temperature and generate a signal corresponding to the existing thermal state. This signal may appropriately be called the "is" signal. Second, the system must perform that set of operations that generates a signal corresponding to the pre-selected thermal value. This signal may be labeled the "ought" signal. Third, the thermostat must perform the set of operations that generates the "is minus ought" or "error" signal, and on the basis of whether this signal is negative or positive, switch a heating device on or off. We shall name the first of these functions whose task is to sense the system context the <u>sensing function</u> ; the second, whose task is to provide a standard or norm, we shall call the <u>normalizing function</u>; and the third whose task is to compare the existing and desired conditions and make a decision among the available options, we shall call the <u>deciding function</u>.

It is apparent from this functional description of the simple thermostatic control system that parts of the functional operations are not performed <u>within</u> the thermostat proper. One basic operation of the normalizing function, the pre-selection of the desired value, must be performed by an external agent such as a human. Should this agent be considered as part of the system? If the systems analysis is made according to system components and sub-systems, the source of the "ought" value would be put into ~~and~~ external black box and the pre-selected value conveniently regarded as a system input. But in a systems analysis made according to functions, it is essential that no operation which is part of the set of operations belonging to the function be treated as outside the system. The delineation of what may be taken as the system boundary depends on this criterion. Systems analysis by components may be atomistic/reductionistic, but systems analysis by functions must remain wholistic.

Let us next consider a more sophisticated control system, one that has the capability of self-modification. Such a system might be, for example, a thermostat that can minimize fluctuations in room temperature by anticipating environmental changes. In one model of such a system the periodic components of the room temperature changes could be harmonically analyzed and their periods and amplitudes supplied to the deciding function which could phase the switching of heating and cooling devices so as to anticipate the expected changes. Failures to anticipate would be used to modify the program through the inclusion of additional harmonics and sub-harmonics of the room temperature pattern. If the temperature pattern proved to be purely periodic then through a sequence of program modifications the thermostat could eventually derive a program which would replicate the temperature pattern and allow the deciding function to anticipate them. In this more sophisticated system a fourth function is present. In addition to the original three operations of sensing, normalizing and deciding, there is the capability of introducing new operations and altering existing operations in the system program. The set of operations by which the system program is modified will be called the <u>modification</u> anticipatory function? function. In the simple thermostat the system program consisted simply of comparing the "is" and the "ought" signals and throwing a switch on or off. There was no way to modify this program. In the anticipatory model in addition to the "is" and "ought" signals a third signal that we may call the "adaptation" signal is fed to the deciding function. The adaptation signal is learned from analyzing the actual temperature changes and is modified whenever it fails to replicate them. The set of operations that generate and modify the adaptation signal belong to the modification function. However, after the modifications have been completed and the program can successfully anticipate, the adaptation signal becomes part of the routine program and its custody is transferred to the deciding function.

It is a general feature of systems that the sensing, normalizing and deciding functions maintain custody and responsibility for their sectors of the system program, while the modification function turns the product of its modification operations over to the other functions once the modifications have been completed. In some systems certain modification processes themselves become routine. The set of operations involved in such modifications are then taken over by the other functions. The modification function has worked itself out of a job, so to speak. So a more refined definition of the modification function would say that the task of the modification function is modification except when the operations of modification have already been learned. It is the residual tasks that are the essential operations ~~of the~~ of the modification function. These are the design of operations for coping with unprecedented situations and developing programs for adapting to them. So long as unprecedented situations arise and so long as the system has not reached some limit of modifiability, the modification function has the job of developing alternatives and creating new options.

The modifications of the anticipatory thermostat were software or program modifications. Systems that modify their hardware components belong to a higher level of the scala. Bio-organisms, in general, are capable of hardware modification but alterations are usually effected in steps through a series of different individuals (evolution) rather than within the same individual. The sets of operations constituting hardware modification through genotype and phenotype phases, though of great importance in the subject of control systems, lie outside the scope of this paper. [2]

Each of the four functions is present in bio-systems, but through inter-functional programming, each involves more sophisticated operations: The sensing of the environment becomes multi-channeled and complex; normalizing involves internal monitoring and operations capable of system repair and healing. The deciding function becomes highly developed and operates on both autonomous and conscious levels. The modification function rewrites programs and becomes especially important in the higher organisms through various types of learning procedures.

At this point, we can characterize the system functions in a more comprehensive way than was possible from the properties of simple thermostats.

The sensing function is primarily associated with operations having to do with the system's interface with its physical context, with sensing, perceiving and data collection, with displaying the present or "is" conditions to the organism. Interfacing is at root information exchange.

The normalizing function is concerned with operations that maintain standards or norms and display the "ought" conditions to the system. This function initiates correction and restoration operations for both system parts and the system whole, guiding them in accordance with reaching equilibrium with the state defined by the norms. Stability is at root standards maintenance.

The deciding function governs established and routine operations, selecting, choosing and switching. It makes comparisons, correlates, groups, etc.) In brief does all operations that constitute administration. Control is at root decision making.

The modification function initiates operations that alter the system's routine operations and norms. It focuses on operations having to do with adaptation to unprecedented situations and is the receiver or the generator of novelty and innovations and the creator of alternatives and options. Modification is at root option creation.

As systems become more complex, the functions acquire additional attributes. In sophisticated systems the functions may more properly be termed "functional sectors" with each of the four sectors containing aspects of the other three functions. In other words functions and functional sectors homologously related in the sense that each functional sector takes on the four-fold functional pattern within its own operations. The homologous nature of the relation between functions and functional sectors can be conveniently displayed using a cross and a cross-crosslet. In the simple cross of Figure 1. each arm represents one of the functions. The right hand arm the sensing function, the upper arm the deciding function, etc.

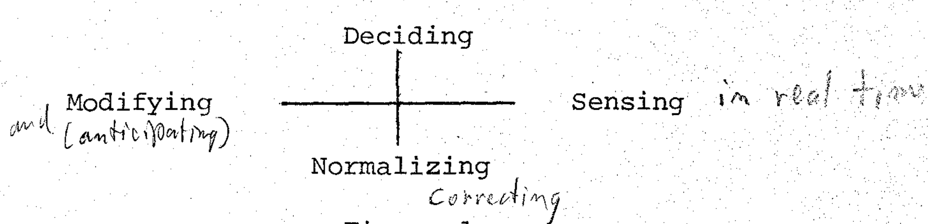


Figure 1.

Functional sectors may be represented using the cross-crosslet of Figure 1b. In this figure the right hand crosslet represents the sensing sector, the upper crosslet the deciding sector, etc. The arms of each crosslet represent the corresponding functions within the sector. The right arm the sensing function etc.

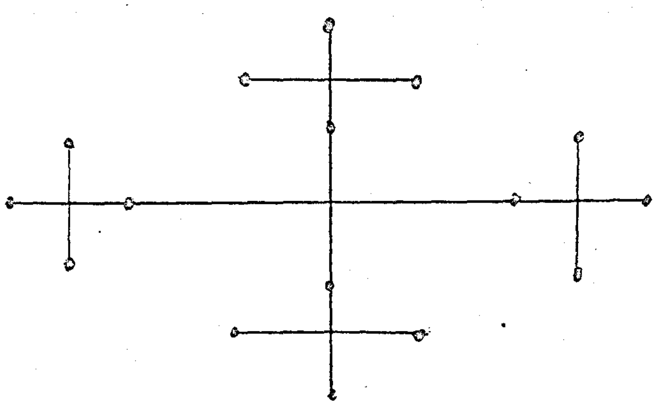


Figure 1b.

Using this representation the crosslet representing each functional sector of Figure 1b. may be amplified as in Figure 2. In the upper crosslet of Figure 2. the three ingredients on which decisions are based--situational data, standards and options-- are displayed together with the types of programs related to each function. The right hand crosslet of Figure 2 shows the distribution of the three types of data collected by the sensing sector. This sector supplies the deciding sector with data required for operations of a routine nature; it supplies the normalizing sector with data required for assessing and evaluating contextual norms and supplies the modifying sector with data of a novel nature or descriptions of unprecedented situations. The lower crosslet of Figure 2. shows the three sources of standards used by the normalizing sector. The standards whose sources are in the present prevailing conditions are shown on the sensing arm of the crosslet; those norms that come from routine and past practice, from tradition, etc. are shown on the deciding arm; and those coming from desired modifications and goals for the future are shown on the modifying arm of the crosslet. In the left hand or modifying crosslet, the three types of innovation and modification are displayed: New and unprecedented experience on the sensing arm; new organization, programs and operations on the deciding arm; and new norms and goals on the normalizing arm.

The cross-crosslet displays the homologies between the functions as constituted on different systems levels. It is not reducible to a tree. The right, left, upper and lower arm positions represent relations in addition to the "boss" or "source" relations displayed in conventional trees. This form of representation will be used throughout this paper for displaying homologous relations between psychological types and societal functional sectors.

The Deciding Functional Sector

Decisions
Routine Programs

Options
Improvement Programs

Situational Data
Data Programs

Standards
Correction Programs

The Modifying Functional Sector

New Practice

Software Adaptation

Unprecedented Experience

New Norms

The Sensing Functional Sector

Routine Data

Unprecedented Data

Data Collection

Data for Norms

The Normalizing Functional Sector

Norms from Operations

Norms form Goals

Norms from Context

Acquisition and
Preservation of Norms

Anticipation
Cultural Tape

Figure 2.

HOMOLOGIES IN SYSTEM FUNCTIONAL SECTORS

Jung's Psychological Types

Many typologies have been proposed to compare the psychological and physiological characteristics of individuals. To mention a few: Hippocrates suggested a typology of physique and temperament corresponding to Empedocles' four basic elements--earth, air, water and fire. Rostan in the nineteenth century recommended a four-fold digestive, muscular, cerebral and respiratory typology. Kretschmer in the twentieth century advocated a system based on the categories: asthenic, athletic, pyknic and dysplastic. That typologies need not be four-fold, we note Sheldon's more recent system based on his Atlas of Men which led him to his classifications of endomorph, mesomorph and ectomorph.[3] Yeats used a system with twenty eight categories while William James divided people into those with tender-minded and those with tough-minded temperaments. As useful as these several typologies have proven for various purposes, our interest is drawn to the typology of C.G. Jung which is based on four psychological functions--sensation, thinking, feeling and intuition--which Jung abstracted from his clinical studies. Jung's studies of psychological types originated in his attempts to help people --husbands and wives, parents and children-- understand their differences. His taxonomy of four basic types depends on the relative development of the functions within the temperament of the individual. A sensation type, for example, is a person in whom the sensation function is especially well developed while the other three functions are under-developed. Jung's system is of central importance in this paper because of the homologies that exist between his psychological functions and the system informational functions.

Jung's four psychological functions may be described briefly as follows: The Jungian sensation function is almost identically the system sensing function, both being the function governing the operations having to do with information acquisition from sensing and interfacing with the physical environment in general. The Jungian *thinking* function is also an homologous extension of the system deciding function. It controls not only the usual lower level system deciding operations but being on a cognitive level is capable of complex logic operations involving several levels of self-reference and all that is usually associated with the operations of thinking. The Jungian *feeling* function plays an analogous role in humans to the system normalizing function in lower order systems. That this is so is not quite so apparent as in the sensation and thinking cases. Feeling for Jung is not a matter of emotion or affect but a matter of like and dislike, a matter of evaluation according to tastes and values held by the individual. Feelings in this sense have to do with judgements of whether actions, people, situations or things come up to expectations or conform to standards. It is in this sense that Jung's definition of his feeling function is analogous to the system normalizing function. Jung's fourth function, *intuition*, is the function governing symbol formation and imaging operations. It has to do with the perception of gestalts, insight into fundamental patterns and the acquisition of concepts and solutions through a "recognition" process--which anticipatory may be multi-sensory or "extra-sensory"--that 'knows what it is looking for as soon as, but not before, it finds it'. The analogy of the intuition function to the system modification function lies in both being the innovational functions. On the psychological level the sources of innovation--new ideas, discoveries, inventions--are the new images that form in the minds of people. System modification on psychological and social levels originates in the innovations deriving from these new images. In this way Jung's intuition function plays the role of the system modification function. [4]

Psychological type may be characterized either by the relative degree of development of the functions in the personality of the individual, the method adopted by Jung, or may be characterized by the principal function that the type performs within the higher order system--organization or society--in which it lives. Both of these ways of characterizing the types are reflected in Table I. The first five rows compare the attitudes and roles that each type emphasizes in a social context. Rows six through nine compare some paradigmatic views, while rows ten and eleven compare anxieties and response to stress.

From the first five rows we get the picture of the sensation type as primarily centered in the external world, stressing action and the concrete. choosing occupations having to do with practical down-to-earth matters. What is important is workability. We see the thinking type as factual and logical, involved in organization and administration. What is important to him is what is true and valid. Feeling types are strong for law and order, for stability and justice. They are the critics and judges of society. Their approach is primarily people centered and what is important to them is what is good for people and society. The intuitive types emerge as creative and innovative people. They point out alternatives, design new approaches, and generate new options. They focus on potentialities and on what may be. What is important is the "big picture" and how we relate to it.

In rows six to nine, we see how the different types through their respective views and emphases create paradigmatic differences. Consistent with the present centered nature of sensing, the sensation type tends to focus consciousness, energy and will on the present. He is a "now" person, living in and for the moment. He has a short memory and discounts both

TABLE I

ATTRIBUTES OF PSYCHOLOGICAL TYPES

		Sensation	Thinking	Feeling	Intuition
1.	Preferences:	deeds and action	facts and organization	rules and values	possibilities and innovations
2.	Emphases:	implementation, getting the job done	procedures, coordination	criticism, correction	alternatives, options
3.	Tends to be:	empirical and pragmatic	logical and rational	evaluative and lubricative	speculative and imaginative
4.	Wants solutions to be:	workable	systematic	agreeable	open-ended
5.	Focus is on:	the realizable what works application	the probable what is true verification	the preferable what is good evaluation	the conceivable what is important signification
6.	View of time:	focus on the moment, "Now" is all	linear, with past, present and future	cyclical with emphasis on precedent	future or extra-temporally oriented
7.	View of change:	probabilistic	causalistic/ deterministic	normative	finalistic
8.	Approach to the future:	discounts the future	future, an extrapolation from past and present	emphasis on stabilization	emphasis on fluidity
9.	Method of validation:	body counts (Lockean)	logical or internal consistency (Leibnizian)	authority, law precedent Cartesian	authority of self Cartesian
10.	Fears:	loss of gratification	loss of capability and self-confidence	loss of relationships	loss of meaning
11.	Response to undue stress:	binges and excesses hoarding	methodical rituals and procedures	depression and illness	withdrawal and fantasy

the past and the future. He feels few ties to either yesterday or tomorrow and projecting his personal view onto the world, considers it to be free of both causal chains and great ultimate purposes. What happens, happens. The world thus seen becomes probabilistic in nature. The matter of validation is usually not a major concern, sense gratification and the pleasure principle in general provide their own validation. However, when something comes up for which validation is required, the sensation type likes to resolve it through body counts: "What is the gang doing?", "What do the polls say?"

The thinking type shares the physicist's view of time--linear with a present dividing the past from the future. He feels that events are interconnected by causal chains and it is knowledge of these chains that lead us to the laws of nature and make science and the application of science possible. The thinking type believes that we can forecast the future by making extrapolations from the present since the laws of nature will be the same tomorrow as they were yesterday. Validation is one of the central concerns of the thinking type. Validity is established primarily through proof of consistency with the established body of knowledge. [5].

Feeling types choose to be governed by precedent and become past focused. They think of time as cyclical with continual recurrence of archetypal situations. [6] With nothing new under the sun, the past provides the keys to the present and the future. The world is not immutable, however, and we can move it step by step into better accord with our norms. The cosmic or collective will to correct and heal is stronger than any causalistic chain. As for validation, it is no problem. We have but to turn to our established codes, to our sacred books and the wisdom of the past to guide us.

Intuitive types, like sensation types, are "liberated" from the constraints of time. While the sensation type frees himself from the past and the future by shrinking time to be only the present moment, the intuitive type, soaring on the reality that for him resides in his own images, leaves the time-line of the physicist and lets consciousness range freely to past, to future, to elsewhere. But since possibilities,in order to be possible, must in some way be linked to the physical world and since there are fewer and fewer far away and unexplored places in which the possible may reside until it is captured and tamed, the possible must increasingly take refuge in the future. Intuitive types have thus become largely future oriented. [7] They feel the finalistic attraction of the system's potentialities to be a force capable of overiding all deterministic/causalistic obstacles. The future is wide open; we are limited only by our visions. As for validation--no need for concern--we know when we are right.

Lines ten and eleven of Table I compare the fears and defense mechanisms of the four types. The primary anxiety of the sensation type is the loss of immediate gratification. A delay or shortage that threatens continuity of gratification triggers such excesses as hoarding, going on binges and indulging addictions. The thinking type's security rests on his ability to perform and his greatest anxiety centers on loss of capability and the accompanying loss of self-confidence. His defensive response to such an eventuality is to exaggerate his normal logical behavior and wall himself about with methodical rituals and procedures, such as locking and re-locking doors, recording, copying and filing trivia, etc. Feeling types fear most of all the falling out of relationship, being rejected. They respond to such a situation by a self-induced depressive illness calculated to regain sympathy and affection. The intuitive type's anxiety is over loss of meaning and orientation. When this anxiety presses heavily they tend to withdraw from the existing world and build new worlds in fantasy to replace the one that frustrates them. Each type's unbalanced emphasis of its own function is usually at the root of its troubles. But not realizing this, it thinks the answer to difficulties is to apply more of what has on other occasions been successful for it, what it is adept in--its own function. This leads to greater imbalance and difficulty. Whence the absurdity of seeing people (and societies) apply in great measure what fails in moderate measure. 'If we just try a little harder, what we have been trying will work.' No alternative is conceivable.

Frequently we encounter such questions as, "Which is the right type?", or "Which type has the correct perspective?". These questions and their like stem from a "type chauvinism" that exists in every culture and sub-culture. For, example, the type chauvinism in the United States at the present time is one strongly prejudiced in favor of sensation types. With estimates that some 80% of our population is of the sensation type, sensation types are better understood in our society and are more liberally rewarded than other types. But basically there is no single 'right' type. All of the types are right when taken together; all are wrong when taken singly. Each is partial and incomplete by itself, needing the others to achieve effectiveness. Every workable social group needs all four types and each individual needs to develop all four functions. Each function is essential to the successful operation of the whole. Whether the system is an individual or a society, the critical matter is <u>balance</u> among the functions rather than dominance by the 'right' function. This does not necessarily mean equal numbers of each type in an organization or society, but means an unimpeded flow of each type's inputs and contributions. The real usefulness of this typology is not as a static indicator, but as a vector showing which functions need most to be developed in order to achieve balance. [8].

Functional Sectors in Social Systems

The importance of the system informational functions and of Jung's psychological types lies not only in the insights afforded into individual behavioral differences but in the illumination they give to the basis of social organization. Although no demonstration of the necessity of an isomorphism between the psychological structure of individuals and the structure of their societies can be made, the reflection in social organization of the psychological patterns identified in individual humans, like the reflection in the shape of a crystal of the structure of its constituent molecules, is an expected development from the point of view of general systems theory. We may hold that our social organizations develop these functions because our psychological natures require them. [9]

Four elemental control sectors are found almost universally in human societies. These can be identified with the labels: Prince, Warrior, Prophet and Judge; or in a highly developed society they are recognizable as the control sectors charged with administration, defense, change and relationship. The ubiquity of this four-fold organization of society may be seen in examples from all parts of the world and all eras. It is present in groupings as elemental as a hunting party of Kalahiri Bushmen whose members consist of a headman, hunter, shaman and clown.[10] The same four-fold social organization is manifested in the city structure of the Mayan ritual center at Uxmal. [11] It appears in the traditions of North American Plains Indians and in the caste systems of India. [12] These control sectors are the systems functions and the Jungian types in social form: The headman-prince-administration sector being the system deciding functional sector and the natural abode of the thinking types, the hunter-warrior-defense sector is the societal sensation sector; the critic-judge relationship sector is the normalizing/feeling sector and the shaman-prophet-change sector is the modification/intuition functional sector. (Figure 3)

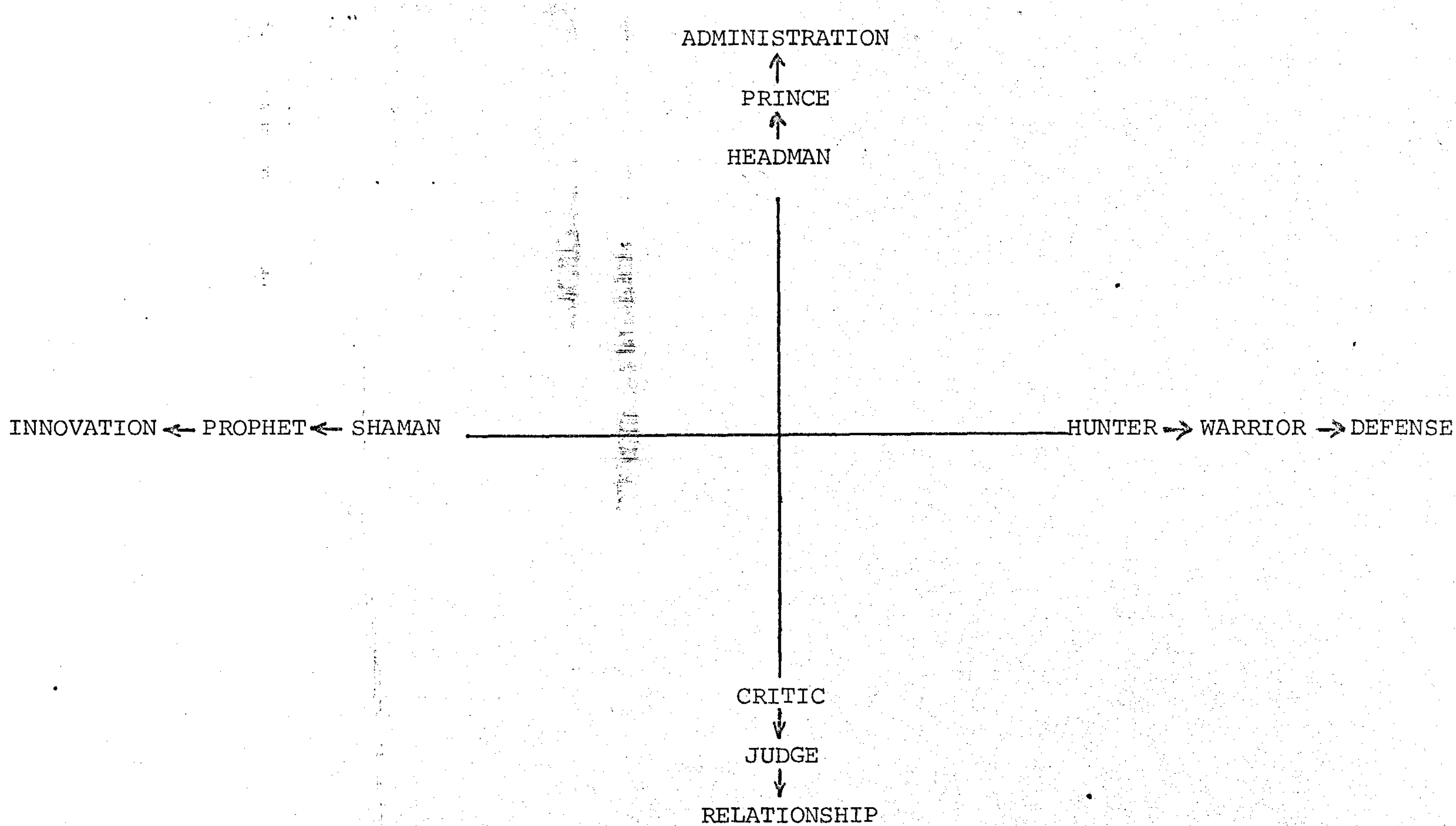


FIGURE 3

FROM CLAN TO SOCIETY

There are many speculative scenarios on the origin of the social functional sectors. We may surmise, for example, that within nomadic hunting clans internal disputes arose over whether to stay with a carcass until it was stripped clean or go after a fresh kill. One choice demanded temporary localization of the clan and loss of freedom of movement. The other choice demanded the willingness to risk going hungry. This decision would bring on disagreements between those types who would feel very uncomfortable if immobilized and deprived of options and those types who preferred to keep risks to clan welfare and stability at a minimum. The future began to be differentiated from the present.

When the saving and the storing of food became a definite viable option nomadism declined and the simple organic hunting party was metamorphosed into a society. This brought about new imperatives: The necessity to protect and defend what was stored, the necessity to count and record, the necessity to share and adjudicate and the necessity to plan and anticipate. Clan became Polis, organism became organization, but the economy alone could not bind great numbers into a cohesive whole. A social mucilage consisting of <u>authority</u>, <u>arms</u>, <u>codes</u> and <u>gods</u> evolved--an adhesive for each psychological type. And with each adhesive a custodian of the adhesive--prince, warrior, judge and prophet The prince was responsible for decisions, the warrior for interfacing with the world beyond the polis, the judge for codifying the norms of the society and keeping relationships in adjustment, and the prophet for staying in touch with the voice of "The Other" and its calls for reform. The four functional sectors had assumed their social forms: Decision and management of the routine, Defense and inter-societal relationships, Stability and intra-societal relationships, and Change, innovation and bridges to the unknown.

Increasing complexity of the social order finds each social functional sector constructing within itself sub-structures that are hierarchically homologous to the whole society. [13] These hierarchical homologies may again be conveniently displayed with cross-crosslets. Figure 4 shows the homologous relations between an administration sector, a defense sector, a stabilizing sector and an innovational sector. We shall here adopt the "S", "T", "F" and "N" notation used by Myers and Briggs in measuring the four Jungian Types. [14] "S" will be used to designate sensing/sensation/defense, "T" will be used for deciding/thinking/administration, "F" for normalizing/feeling/stabilization and "N" for modifying/intuitive/innovation. The upper or "T" crosslet displays government as a particular societal administrative functional sector. The upper "T" arm of the crosslet corresponds to the executive, king or president, who is responsible for administering the laws. The left-hand "N" arm corresponds to parliament, the source of new laws. The right-hand "S" arm represents law enforcement and the lower normalizing "F" arm represents the courts and the law itself--the constitution and the basic body of law and procedures.

The particular "S" functional sector illustrated in Figure 4 is that of the military. (Other important "S" sectors that might be displayed are intelligence, diplomacy and trade.) Within the military sector, the upper "T" arm corresponds to command, the left-hand "N" arm to strategists and think-tank experts who devise new operational procedures and introduce new weapons systems; the "S" arm corresponds to the effective fighting forces and to the operational weapons systems themselves. The lower "F" arm corresponds to the normalizing framework adopted by those that "play the game" of war. This arm would correspond to such items as codes of chivalry among medieval knights or World War I aviators, or in the present day to the Hague and Geneva conventions delineating the rules of war or to the sophisticated interplay of overt and covert threats and postures known as "nuclear deterrents".

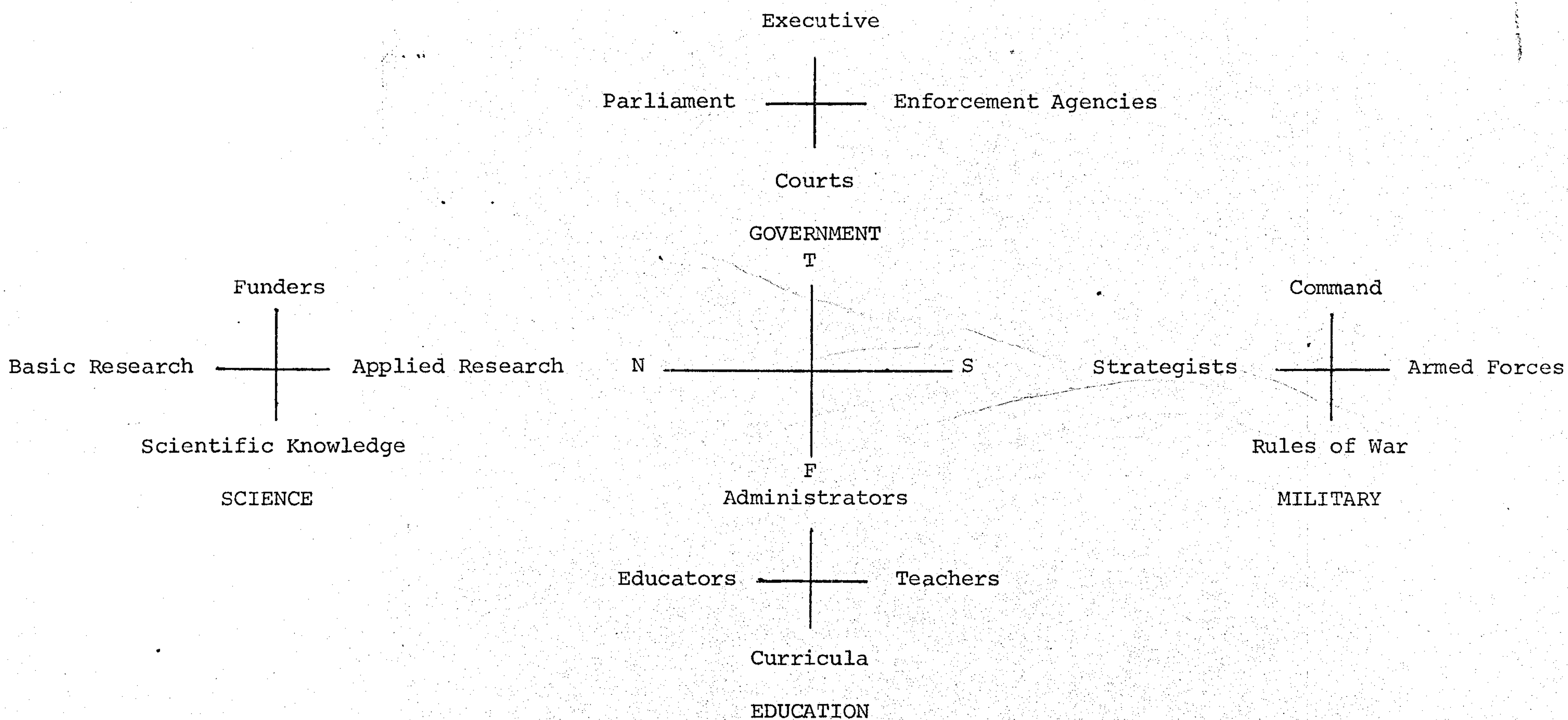


FIGURE 4

Hierarchical Homologies in Social Functional Sectors

The example chosen for the lower "F" crosslet is education, which is a normalizing sector whose task is to preserve standards and cultural forms through inculcating the young. In the educational crosslet the upper "T" arm corresponds to school administration. The left-hand "N" arm represents educational experimentation and innovation; the lower "F" arm corresponds to curricula or the body of information that is selected to be taught. The right-hand "S" arm represents the teachers and students themselves. Other examples of "F" functional sectors are institutionalized religion, the law, and the media, all of which set, preserve and disseminate cultural standards and norms.

The innovational sector picked for the left-hand "N" crosslet is that of science and technology. In this crosslet, the "S" arm corresponds to applied research and to that type of research that consists of filling in the details of a "Kuhnsian Paradigm". The left-hand "N" arm corresponds to basic research and the processes that lead to new paradigms of science. The lower "F" arm represents the established body of scientific knowledge, which is the basic yardstick against which all innovation in science is measured. The upper "T" arm stands for the "top-down" administrative elements that direct research through funding and assignments of priorities. Every field has an innovational sector which could be represented by an "N" crosslet. But, besides science and technology, the innovational sectors with broadest relevance are those of politics, art and religion. [15] Religion as an innovative sector must be distinguished from institutionalized religion as a normalizing sector. "N" type religion has to do with philosophy, world views and the chain of attitudinal and behavioral modifications that ensue from a worldview modification.

We leave hierarchical homologies and the "game of quad" by pointing out in Figure 5 the emerging branches of systems theory that correspond to each of the four functional sectors.

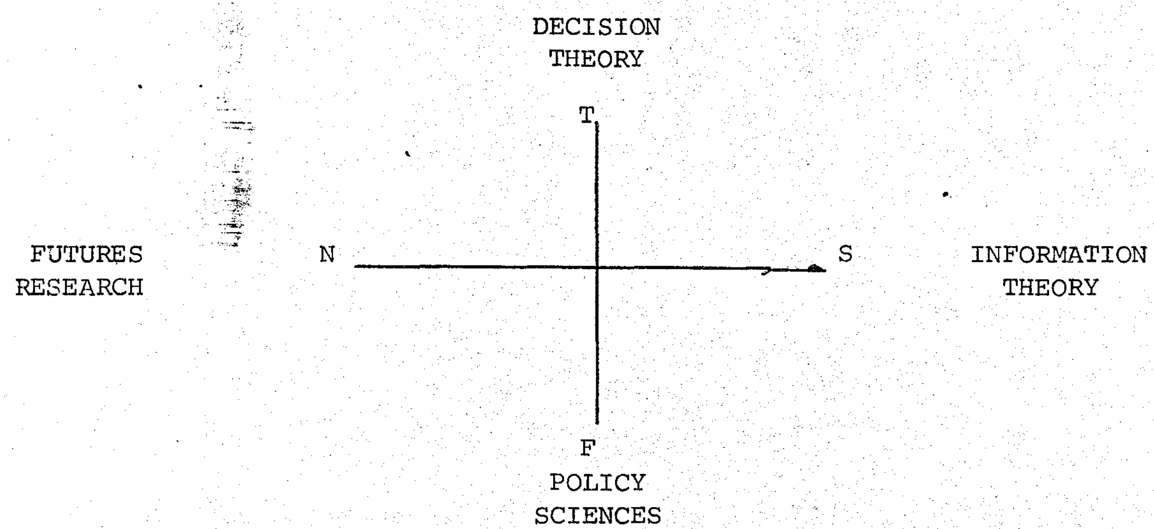


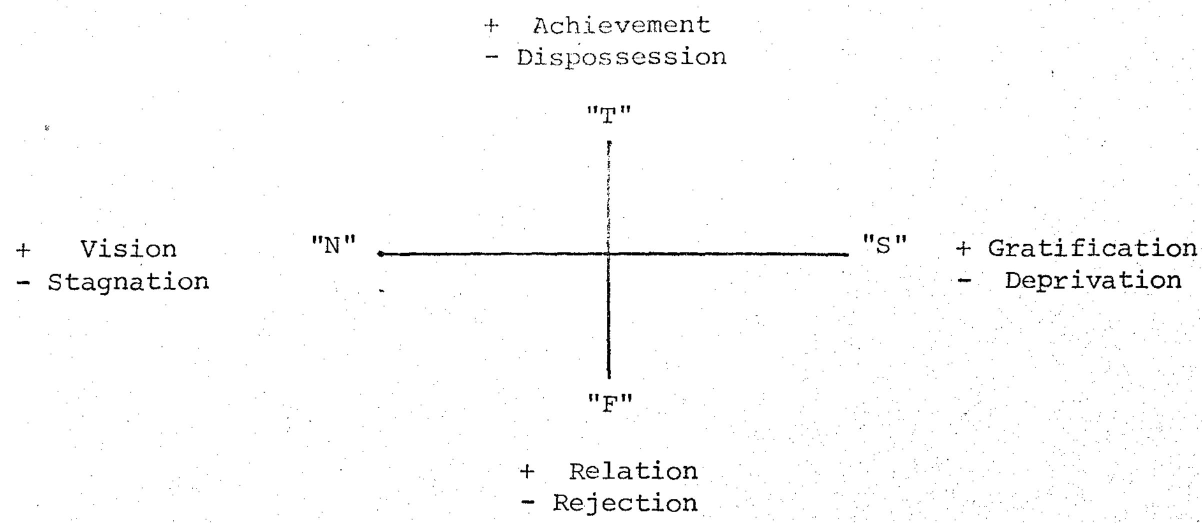
FIGURE 5

The Four Functions as System Disciplines

Dynamics of Normative Systems

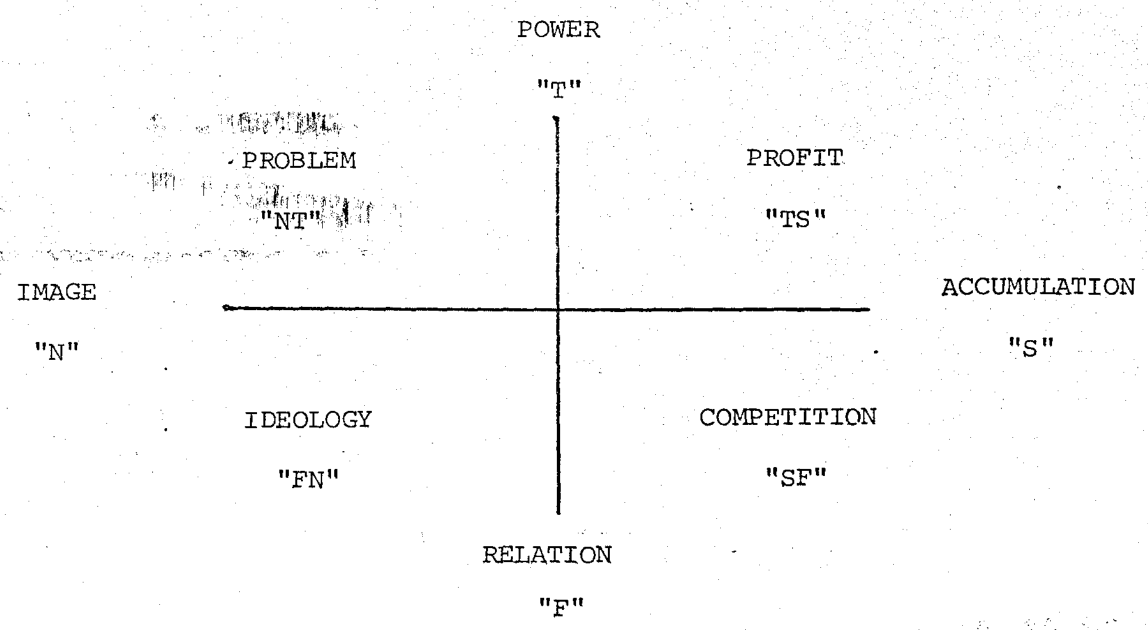
In the survey of psychological types it was noted in Table I that each type has characteristic anxieties, typical defense mechanisms and favored behavioral patterns for coping with stress. More generally, each type possesses a characteristic motivational base or dynamic. A dynamic may be thought of as a'psychological fuel' from which the individual obtains energy and drive. Each type may run on all of the fuels but responds preferentially to a particular one. For example, the sensation type's basic anxiety--loss of gratification--is a key to those things that particularly energize him. His dynamic is primarily sensory gratification. He is energized by those experiences which promise immediate gratification, consistent with the findings of his being "now" oriented and a discounter of the past and the future. But the drive of sensory gratification is only one side of the coin. The sensation type is not only driven by sensory gratifications, but is also strongly energized to action when there exists a threat of deprivation of his gratifications. For him a crisis is a loss or delay in the flow of those items upon which his gratifications depend. Thus each person is motivated by both an aspiration and a fear--the two meta-dynamics--and all of the type dynamics take on both a positive and a negative aspect. In the case of the sensation type, the positive or aspiration dynamic is gratification , while the negative or fear dynamic is deprivation.

The positive dynamic for the thinking type is achievement--college degrees, home ownership, executive positions or is performance--all A's on the report card, records in production, increased profits. The negative dynamic is the fear of dispossession and displacement--threat to authority, position or acquisitions. The positive dynamic for the feeling type is good relationship--friends, belonging to the group, status. The negative dynamic is the fear of rejection, ostracism, exile. The intuitive type is



POSITIVE AND NEGATIVE PERSONAL DYNAMICS

FIGURE 6.



COMPOSITE SOCIETAL DYNAMICS

FIGURE 7.

positively energized by images, visions, dreams of what might be. His negative dynamic is the fear of closed-endedness, the collapse of all opportunity for modification, fear of ossification and stagnation. These personal or psychological dynamics--positive and negative--are displayed in Figure 6.

On the societal level each of these dynamics not only represents the dominant drive of groups of individuals of each type but, depending on which psychological type(s) dominates the culture, characterizes the society itself through the establishment of its principle life styles, norms and definition of success. A 'pure' S-type society would be one in which accumulation of material possessions is the condition of satisfaction and the measure of success. Collectively the S-society is the consumption society. In a T-society the degree of power or control over decisions is the measure of stature in the society. The T-society as a whole measures its success in terms of its power and control over societies outside itself. Such a society is an imperialistic society. In an F-society, status, membership in castes and clubs, possessing the proper pedigrees and titles would be 'in'. Collectively, such a society tends to be chauvinistic. In the N-society, contributions--artistic, scientific, humanitarian--are the principal sources of personal satisfaction and the basis of recognition. The n-society's monuments--its pyramids, cathedrals, courts of law, footprints on the Moon--would be the base of its collective meaning.

Of course, there is no society of a single pure type. Such a society could not long survive. We recognize the existence of each of these dynamics in most societies. What differentiates one society from another is the relative emphasis placed on each dynamic. It is from the mix and blend of these four type-dynamics that the principal societal composite-dynamics emerge. In Figure 7. the four type-dynamics are displayed together with their composite-dynamics--

profit, competition, ideology and problems--which have become the basic societal dynamics.

The S-type gratification and accumulation dynamic combined with the T-type drive for organization and power leads to a dynamic which expresses both. This is the profit motive, which is the principal energizing fuel of the S-T technological society in which we live. Profit, measured in return on investment per annum, measures both accumulation and the success of organization and management. The fact that it is a rate rather than an amount is a feature more in accordance with T view of time than S views, but the short time span of one year keeps the tensions of S types for gratification from building to levels of high dissatisfaction. Most present economic theories are S-T theories. Wealth is measured by material resources (S) and capital or tools (T) and does not include such F and N types of wealth as knowledge and problem solving capabilities. The theoretical economic man is a combination of an S-type consumer and a T-type businessman who always knows and looks out for his own best interests.

The tension of competition--of an unresolved contest--is a powerful dynamic that appeals primarily to S and F types. Brute behavior through normalization has been tamed and given many channels in which to flow. The blend of the S type's drive to acquire and the F type's need for rules of fair play creates competitive games that include not only sports but business, careers and war, each with their definitions of win and lose. Great difficulties are encountered if the game changes and the old definition of "win" no longer obtains. It is in this same S-F quadrant (Figure 7.) that the dialectical dynamics of Heracleites, Hegel and Marx find their support.

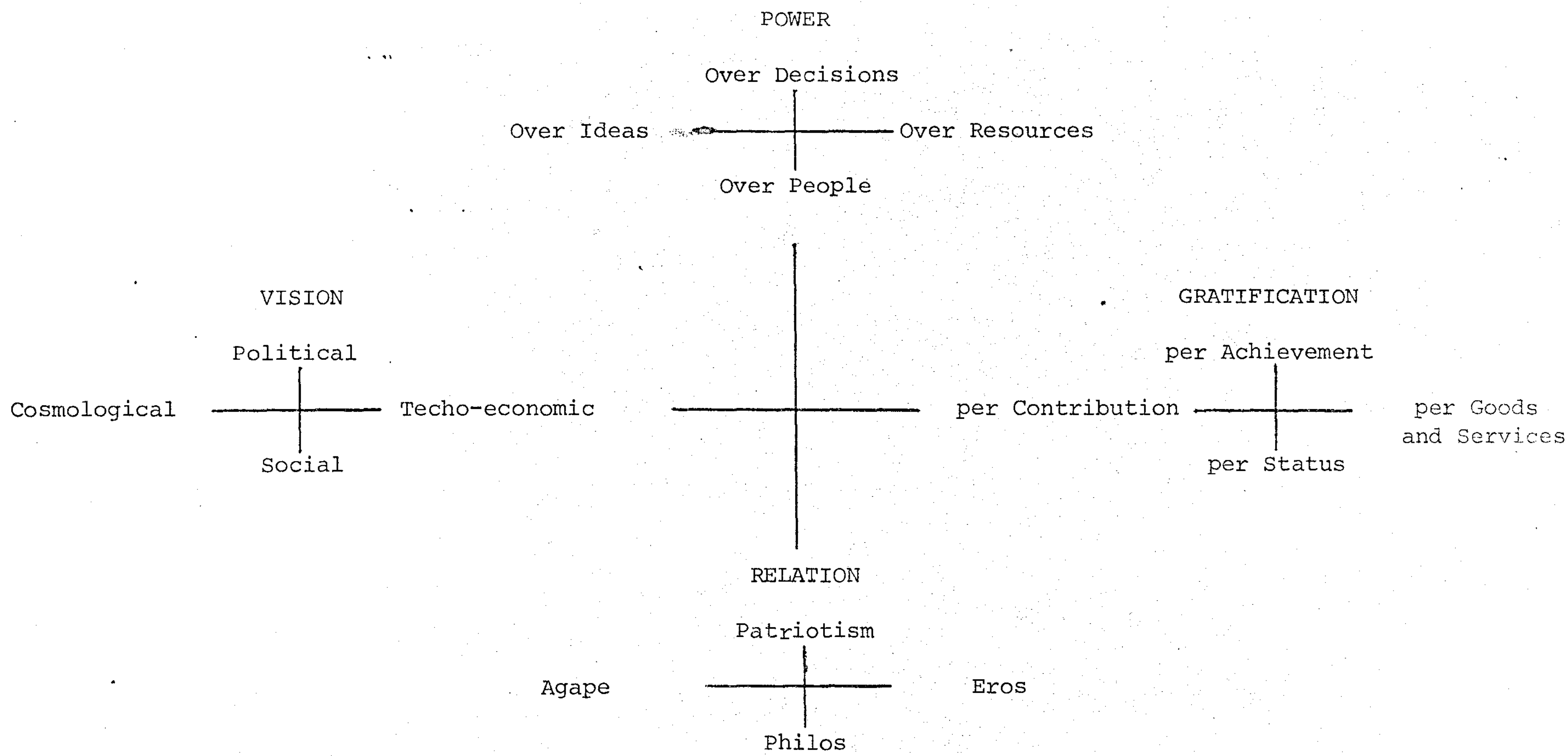
The marriage of N images and F norms gives birth to ideologies --those great 'should be's ' that fire both the imagination and the blood: The 'Alabaster cities that gleam undimmed by human tears', the City of God, the Thousand Year Reich, the World Revolution. When the symbols that represent these ideologies--stars, stripes, crosses, swastikas, sickles, hammers-- march into view, hearts pound, throats lump, tears swell. Psychological energy of great power flows, the parade is joined, the banners move forth and the world is edged a step closer to the dream.

Finally there is the dynamic of the unsolved problem, from the puzzle that cannot be set aside to the timeless mysteries of the cosmos. With the funnels of intuition and the sieves of analysis, N and T ally to meet the challenge of the unsolved. But the problem-dynamic does not cease with the solution of the problem, for more problems grow, Hydralike, for every one that is solved. Flags fade, images cease to energize, acquisitiveness becomes satiated and the competition subdued, but problems persist. Like a breeder reactor, the problem-dynamic generates more fuel than it consumes. It has been claimed that problem creation is the central dynamic of civilization building. [16] "A man on the moon in a decade", was a N-T challenge issued by a President of the United States to an S-T society. It was met , but the S-T society could never fully grasp the meaning of the enterprize and was unable to gain satisfaction from it nor accommodate it to its S and T yardsticks. It appears that the Apollo Program took care of most Americans' "N-T" needs for some time, and the relatively small "N-T" sector of American society must now do its thing on a more modest scale for some time.

Homologies between type dynamics and societal dynamics emerge in many combinations. One such set is displayed in the cross-crosslets of Figure 8.

The <u>power</u> dynamic is centered on the control of four types of access: Access to decision making (political power); access to resources and capital (economic power); access to information (cultural power) and access to rights (judicial power). Other forms of power, such as military power, depend in the long run on the four basic powers. The importance of political power and the tendency for it to be both monopolized and monopolistic was clearly recognized by the drafters of our Constitution and its Bill of Rights. Their recognition of the basic nature of the other three powers was not so comprehensive or perspicacious and much of our subsequent political history has focused on the issues of access in the other three sectors. Economic monopolism has long been an issue in the Congress and in the courts, but today focus has largely shifted to control of access to information and civil rights. Control of access to information takes many forms. It involves the media, education, and government itself through such issues as protection of news sources, selection of textbooks and executive priviledge. Control of rights involves such issues as abortion, drug use, vitamins, invasion of privacy, questions of to what extent should people's bodies and minds be their own to do with as they please. The central theme of <u>access</u> is fundamental to this crosslet. The decision function here takes the form of closing and opening doors.

The gratification dynamic which is an "S" dynamic has its S,T,F and N arms. The peculiarly S aspect of gratification is the accumulation of goods and services, which are the key to most sensory gratification. The T aspect of gratification is in achievement--production, sales, circulation, membership etc. The F aspect of gratification lies in social and relational status--clubs, exclusive neighborhoods, family trees, etc, through membership, rank, position etc.



HOMOLOGIES: THE POSITIVE DYNAMICS

FIGURE 8.

The N aspect of gratification is through contribution, the number of scientific papers published, the number of exhibitions held, performances given, souls saved. The theme of counting and *number*--cardinal and ordinal, body counts and primacies--is central to gratification.

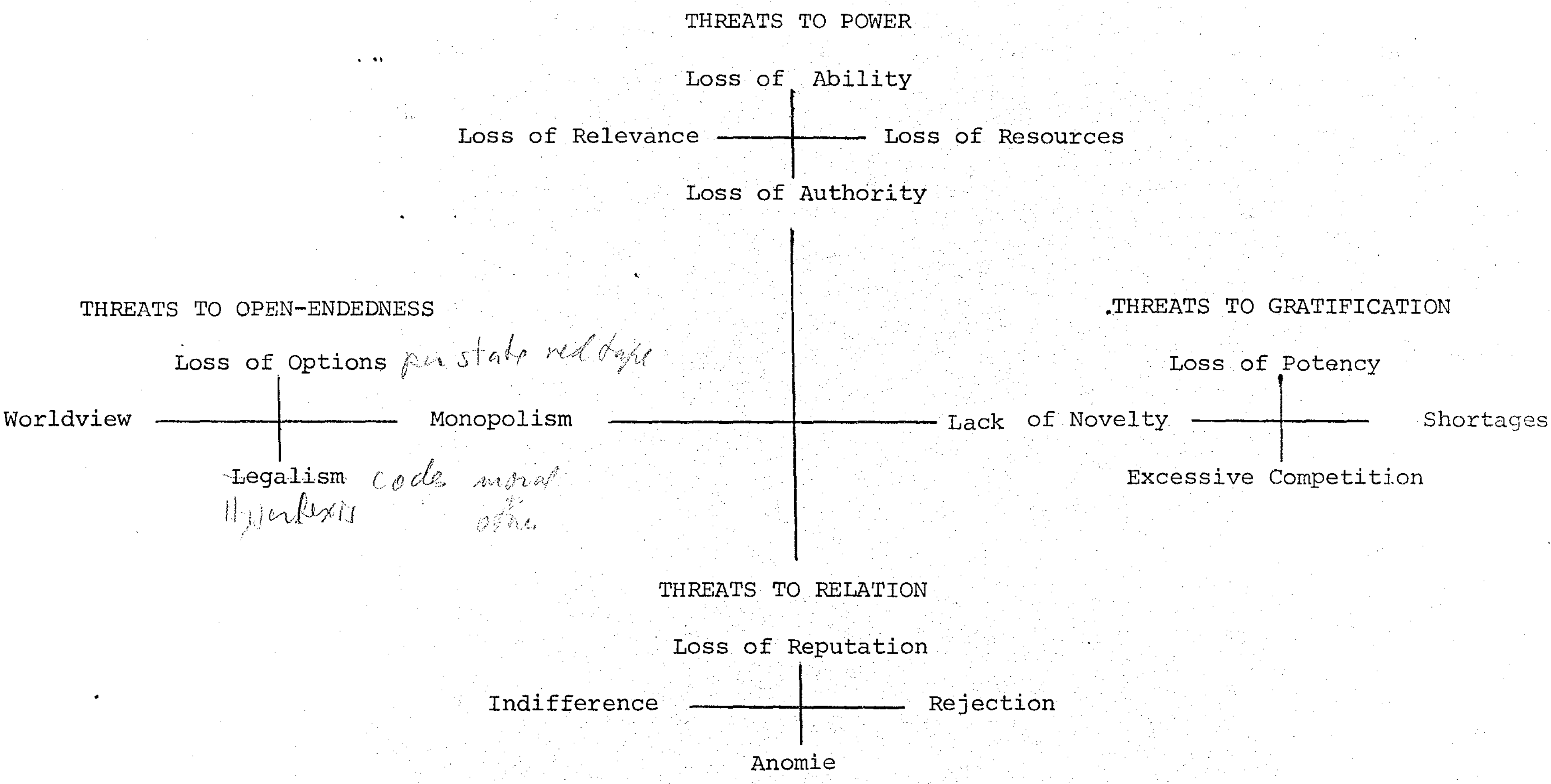
The relational dynamic may be illustrated through the various aspects of *love*, the strongest relational adhesive known. The S aspect, sensual and physical love,is symbolized by Eros. The F aspect, love of humankind and love of learning and cultural heritage, is symbolized by Philos. The T aspect, love of country (or the organization) by Patriotism and the N aspect, love of God or whatever name one prefers for the "Other" by Agape. The central theme of this crosslet is unity, joining, bringing together.

The visions of "N" may take the T form of imagining some political system that would combine liberty, justice, peace and effectiveness or take the S form of new cities of breathtaking beauty replete with dream machines to take care of all economic matters. They may take an F form which visualizes new people and new societies--Ubermensch and Utopia. Or they may seek a N aspect, a new worldview that removes the scales from our eyes and allows us to behold the world and humankind truer form. The theme that courses this crosslet is the construction of bridges to greater possibilities--what we might become.

The golden ages and the golden moments of history have been those in which the Graal of positive dynamics led humanity to higher plateaus. But of the two meta-dynamics--aspiration and fear--fear has proven the stronger. Our societies are based on the institutions of fear--the military, the police and insurance. In history's Skinner Box the stick has been more prevalent than the carrot. For many, and perhaps for most, threats or actual blows from the stick provide the only dynamic. Whereas the positive dynamics contain their energy within their images, the negative dynamics energize not through the image itself, but through the reaction to it. The perceived image triggers a fear that in turn energizes the response. Figure 9. displays the homologies of the negative forms of the dynamics in their perception phase.

Those who possess or compete for power perceive threats to their position in the form of loss of their ability to perform (T), loss of the material resources necessary to maintain their position (S), loss of their authority (F) and loss of relevance (N). Authority is the mystique of power. It is one of the adhesives that makes the social order work. It is rooted in the divinity of the emperor, in the divine right of kings, in the awesomeness of high office. When authority crumbles through ineptitude, corruption or loss of respect, the positive dynamic of power fast disappears, only habit, fear of or actual application of force permit the exercise of power to continue. But history knows no power that long survived loss of authority. Loss of relevance is even more deadly to power than loss of authority. It comes from obsolescence. There is no challenge to the power, no rebellion, no revolution; the parade just passes by. Support, resources and authority move elsewhere. Though oftimes figureheads remain, many are the hierophants, chieftans, committees and vice presidents who have experienced such displacement of power. The theme of this threat is <u>loss</u>.

The threats to gratification are perceived in shortages and delays in the supply of goods and services (S), in the loss of potency or the ability to experience gratification (T), in an excessive competition that demands more energy than it generates (F), and in the lack of novelty to stimulate, titillate or inspire continued gratification (N). Akin to the effects of sensory deprivation, when there is no novelty the Weber-Fechner Law in time reduces all gratification to boredom. The essence of this threat is deprivation.



HOMOLOGIES: THE NEGATIVE DYNAMICS
PERCEPTION OF THREATS

FIGURE 9.

The T-like threats to relation lie in the erosion of admiration and respect and in the loss of reputation which, like authority, is one of the mystiques on which society is built. The S-like threats reside in the fragmentation of social groups, in the rejection of those who are different, of those who are not of immediate use or whose use is not perceived. The F-like threats are in being cut off from heritage, from cultural traditions and from the past, from drifting without cultural moorings and direction --from anomie. The N-like threats arise in the relational stagnation of cynicism and indifference to others, to what is known, and even to self. Alienation is the essence of the threat to relation.

The threats to open-endedness, modifiability, opportunity and progress lie in the freezing up of options through political or administrative myopia and fears (T). They lie in the disappearance through monopolism of the market place with its free flow of competitive goods, ideas and services (S). They arise whenever an excessive legalism invades every aspect of life, restricting initiative of all sorts (F). And lastly, threats to open-endedness reside in the unquestioned assumptions that are implicit and explicit in cosmologies and worldviews; in the restrictions contained in unchallenged images of man and the world (N). The essence of this threat is stagnation.

A threat having been perceived, the second phase of the negative dynamic is the arousal of the energizing fear which puts into motion typical sets of responses. These responses frequently create a positive feedback situation that aggravates the threat and which in turn amplifies the fear and the responses. The response phase of the negative dynamics is shown in Figure 10.

POWER THREATENED

Isolation

Inquisition — Seizure

Suppression

STAGNATION THREATENS

Revolution

Iconoclasm — Anarchy

Nihilism

GRATIFICATION THREATENED

Hoarding

Vigilantism — Looting

Selfishness

RELATION AND STABILITY THREATENED

Nationalism

Crusades — Chauvinism

Legalism

HOMOLOGIES: THE NEGATIVE DYNAMICS
RESPONSES TO THREATS

FIGURE 10.

When power is threatened, typical negative responses are the erection of protective walls around the decision process, the isolation of decision makers from any inputs that carry the aroma of the source of threat (T); the cutting off of funds and the confiscation of any resources that may be taken from real or imagined sources of threat (S); the supression of opposition and dissent through legal and illegal harassment and the subversion and abolition of the legal processes that are supportive of opposition and dissent (F); the conducting of witch-hunts and inquisitions, spying, wire tapping and censorship (N).

When gratification is threatened, fear builds up an overiding self-centeredness and extreme indifference to the fate of others. All concern focuses on "Number One". In this state of relational collapse and panic, hoarding, looting and vigilantism ensue. In this sector there is little difference between the response to a threat of deprivation and a threat to life itself.

The threat of the collapse of relation and breakdown of social stability, stimulates the negative response of projecting an enemy. When the positive social adhesives fail, recourse is had to the 'bad guys' and'good guys' model--them and us, those out there and we in here. In practice this negative dynamic may take the form of extreme nationalism, flag waving, super-patriotism, even war, projecting the enemy on other states (T). Or it may take the form of chauvinism, projecting the enemy onto other races or minorities (S). It may take the form of crusades against those subscribing to other ideologies, religions, political and economic philosophies (N). The power of this particular negative dynamic has permitted peoples with obsolete and decadent positive relational adhesives long to continue to survive and maintain their social groupings.

Othertimes when the positive adhesives fail and social stability is threatened, law and order is eulogized and an excessive legalism in unleashed (F). But as with authority, when the positive relational glue, the social covenant to obey the laws is gone, the law continues to survive only through threat and force, and these can never sustain it alone.

When stagnation threatens, and the positive images have no soil in which to take root, the "N" sector responds with a flowering of compulsive negative images that interact with the T and F responses in a deviation amplifying manner.. The threats to power and stability result in a repression that the N's perceive as stagnation. Their responses to get the social order off dead center through revolution (T), anarchy (S), nihilism (F) and iconoclasm (N) threaten power and stability further. This results in still more repression and'law and order'. Here the negative dynamics bring the functions into destructive confrontation. The four functions, all of which are needed for the successful operation of the system, when excessive imbalances build up, no longer operate for system health and survival but for its destruction. What the psycho-therapist has learned about functional balance, the politician and political scientist could well heed.

Conclusions

Generalization of the four essential functional operations that are present in elemental control systems leads to a powerful integrative schema that allows systems on all levels to be compared. The "TSFN" schema is able to bring into homologous relation a wide variety of independently developed system typologies and models. The four functions appear in one form or another in personality and temperament typologies; modes of cognition and validation, models of societal structure and political procedure, schools of psychotherapy and futures research. The validity of the schema derives from its independent abstraction from several sets of diverse data and from its ability easily to subsume additional taxonomies and typologies. At this point one suspects that the four-fold "TSFN" schema stems directly from some deep principle that governs the structure and behavior of all organisms and organizations. Whether this proves to be true or not, the schema has great heuristic value for the analysis of relations in normative systems.

The necessity of each of the four functions, T,S,F and N to the successful operation of every control system becomes in normative systems the necessity of functional balance between T,S,F and N. This necessity is widely recognized in psychotherapy [17] but not in political and economic theories. It is, therefore, in the analysis of the malfunctions in organizations, communities and societies that the TSFN schema promises to have its most fruitful applications.

The schema is of importance in conflict resolution. The homologies between psychological types and societal control sectors show why the administration, defense, academic and research sectors within a society encounter the same communication difficulties that arise from paradigmatic differences. [18] An understanding of the differences in the types, the functional emphases and the necessity of balance could go a long way toward establishing effective communication and resolving value differences.

Equally of importance is the application of the schema to the functional emphases within our society and the analysis of how imbalance leads to breakdowns. Although the Founding Fathers were never pleased with the mechanism of majority rule for ultimate decision making, they adopted it as likely to be in the long run the most protective of individual rights. It was not recognized, however, that in our culture where the vast majority is of sensation type, that majority rule would inevitably result in the dominance of S-type values, S-type dynamics and an S-type economic system with S control of the purse strings. This imbalance reflects itself in such items as a greatly over-expanded military establishment, emphasis on consumerism and nearly exclusive focus on short range programs. Everything must be justified in terms of an S-type accounting system. Even research must be shown to be cost-effective in terms of the gratification dynamic. T, F and N concepts of wealth, such as knowledge, size of option space, and problem solving capability go unrecognized or are discounted. Better understanding of the functions and the importance of each should serve to give our social and economic orders the functional balance they desperately need.

Finally, the "TSFN" schema may provide us with a theoretic base on which new axiological, political and economic paradigms can be constructed to replace those that are now collapsing all about us.

Notes and References

1. "Amidst all the variations of system and orders, certain general types and characteristic relations can be traced." This quotation from Josiah Royce is a truism. The tracing of commonalities among sets of different things is often possible, but it is also often misleading. Tracing is not enough. For such characteristic relations to be valid they must be formulated on an abstract level from a few specifics and shown to apply in every specific. Commonalities that cannot be abstracted are but curiosities and coincidences, and abstractions that cannot be applied beyond the cases from which they were formulated are but shorthand notations.

2. The four basic system functions have to do with individual systems. They govern operations taking place entirely within the life span of the system, operations such as metabolism, growth, learning and adapting. Additional functions are involved in the modifications that occur in a sequence of systems, such as a hereditary sequence. Whether these evolutionary or hardware modification functions are homologous to or reducible to the four basic systems functions is an open question.

3. Calvin S. Hall, Gardner Lindzey, Theories of Personality (New York, John Wiley and Sons Inc., 1970). Chapter 9.

4. Whether the source of innovation and novelty (new images) must have a component outside the system or whether true novelty can originate through a complex sequence of internal operations is another reductionist question. The question of reductionism in the present instance is: Can the modification function be generated through sequential iterations of the other three functions or does it contain irreducible operations of its own? The system sensing ("S"), deciding ("T") and normalizing ("F") functions can operate on an elemental

(note 4. continued) level, as in the simple thermostat, without either a time signal or a memory. Both of these features are essential to the modification ("N") function in the adaptive thermostat. Since it is difficult to see how a time signal or a memory can be generated from elemental S, T and F operations, reductionism does not seem to have the answer in this case. This matter is of central importance to General Systems Theory. There are many who seek to define a GST in such a way as to be derivable from the properties of simple control systems, i.e. from S,T and F. The minimum base for a GST may be S,T,F and N. For a good discussion on the external vs. internal generation of novelty see M. Bunge, Causality, Meridian Books, 1959, Chapter 8.

5. Philosophical thinking seems to reflect the psychological types: Positivism, a "T" school; phenomenology, an "S" school; and the modes of knowing in ancient cultures "F" schools (see H. Frankfort, Before Philosophy) With regard to validation, sensation types prefer Churchman's Lockean approach, thinking types Churchman's Leibnizian approach. Feeling and intuitive types belong in Churchman's Cartesian category in that both hold that "God will not allow us to be deceived". (See C. West Churchman, The Design of Inquiring Systems).

6. Osmond, Yaker, Cheek (Eds.) The Future of Time (Doubleday, 1971) Mann, Siegler and Osmond,"Four Types of Personalities and Four Ways of Perceiving Time", Psychology Today December 1972. Also of relevance here are H. A. Linstone's four basic groups: Discounters (sensation types), Extrapolators (thinking types), Goal Setters (feeling types) and Cyberneticists (who are gestaltists and are intuitive-thinking types). H. A. Linstone "The Paradigms of Futurists" this volume. Rosalie Cohen's excellent work on types also comes up with the same four identifiable categories: Analytic (thinking), Flexible (intuitive), Concrete (sensation) and Relational (feeling). R. Cohen "Four Paradigms:Their Consequences" this volume.

7. The possible may also take refuge in the past. Atlantis, pre-historic astronauts, secret powers of the Great Pyramid etc. all utilize the mists that enshroud the past to give images a place in the physical world. Winston Churchill once said, "Even if the Arthurian legends are not true, they ought to be."

8. It is also of interest that the bias of each psychological type is reflected in one of the principal schools of psychotherapy. Freud's pleasure principle which views the gratification of biological needs as the primary motivation is a sensation type bias. Adler's emphasis on the power principle reflects the thinking type's concern with control. Sullivan and Horney's need to belong supplies the basic principle for a psychotherapy with the feeling type bias. The existential schools of psychoanalysis, such as those of May, Rogers and Frankel emphasize the intuitive type's concern to meaning and authenticity. Jung subsumes all four.

9. While social systems may well reflect the psychological structure of their constituent human elements, a deeper question is involved. This is the question of which is primary--the psychological types or the system functions. Are the types the manifestation of the four basic functions on a psychological level or do we impose the four functions upon all systems because of the nature of our psychological structure. After all it is we who design the thermostats. But regardless of which is primary, the function-types provide a schema of great integrative usefulness.

10. "The Hunters", John Marshall's film describing the pursuit of a giraffe by a hunting party of South African Bushmen, dramatizes the four types and their functions within an organic group of individuals. The 'clown' of the film is the clown as social critic, the Chaplinesque clown with his mirror ever ready to reflect the foibles and absurdities in every situation.

11. The four centripetal forces historically leading to the formation of cities have been: security, facility of administration, trade and ritual. These activities are frequently reflected in city plans and architecture. cf. A. Wilson, "The Future of the City", AIAA Lecture Series, Volume 12, p17-21, 1973.

12. Medicine Wheel Myths of the Plains Indians disclose an intimate familiarity with the psychological types and functions. Unlike the Jungian arrangement, the Medicine Wheel places "T" opposite to "S" and "F" opposite to "N". H. Storm, Seven Arrows, N.Y. Ballantine Books, 1972. See, for example, p 68 ff.

13. An excellent study of this phenomenon is given by William Irwin Thompson in his book, At the Edge of History, N.Y. Harper and Row, 1971. Thompson develops a convincing four-fold homologous hierarchy modelled in part on Marshall's film, "The Hunters" and in part on the types in W.B. Yeats' "A Vision". Thompson's model connects to Jung through Ego, Self, Anima and Shadow, rather than through the homologies with Jung's psychological types as developed here. I want to here acknowledge my indebtedness to Thompson and his brilliant integrative insights, which were the inspiration for the present model. I hope that both models will serve to stimulate further development and perfection of this important schema.

14. Isabel B. Myers, "The Myers-Briggs Type Indicators", Princeton educational Testing Service, 1962.

15 A highly original and comprehensive model of political processes has been developed by Herbert J.Spiro, "Comparative Politics: A Comprehensive Approach", The American Political Science Review, vol. 56, no. 3, 1962. Spiro finds that political procedures and issues naturally divide into four phases and categories. Four political goals emerge that are readily identifiable with the four functional sectors of the present paper: stability (F), flexibility (N), power (T) and effectiveness (S). Spiro's four political styles are homologous to the functional sectors: Pragmatism (S), Ideologism (T), Legalism (F) and Violence (N). I wish to thank Mr. Spiro for alerting me to his early contributions to this schema.

16. Matthew Melko, "Problem Creation: The Central Dynamic of the Civilizational System", Paper presented before the Society of General Systems Research, Geneseo, N. Y. Sep't. 29, 1972.

17. "But any person who perceives from only one of the Four Great Directions [of the Medicine Wheel] will remain a partial man." Seven Arrows, loc. cit. The recognition of the importance of balance is a recent discovery of the scientific culture of the West. It has long been known to others.

18. Magoroh Maruyama, "Paradigmatology and its Application to Cross-Disciplinary, Cross-Professional and Cross-Cultural Communication", "Three Paradigms among Planners: Hierarchists, Individualists and Mutualists" This volume.

6 TS

THE PROPHET, THE PLANNER AND THE FUTURIST
by Albert Wilson

Talk given at the Center for Futures Research,
Graduate School of Business Administreation,
University of Southern California
January 29, 1976

Preceeding the key year in history whose bicentennial we are now celebrating was a decade of extensive and intense debate. The taverns and coffee houses were filled with men questioning and arguing the rights of individuals and the nature of governments. The creative events that we associate with the Founding Fathers were not the result of lobbying, plea bargaining and back room deals. They resulted from a decade of creative dialogue and searching debate over not only the pragmatic but the philosophic issues that underlie the political order. When it finally became evident that the alternatives open to the colonies under the crown were not acceptable, a long search began for a different set of alternatives --alternatives without the crown. It was an intellectual, tour-de-force to imagine such radical political alternatives and an even greater tour-de-force to construct a framework in which these ideas could viably operate. This could come about only as a result of exploring the foundations on which human-social orders are based.

Two hundred years later we are faced with a parallel situation. It is becoming increasingly evident that the alternatives open to us within the constraints of our present institutions, procedures and world view are not viable and that we too must seek a broader set of alternatives, those afforded us by some new world view. It will again require an intellectual tour-de-force to find a world view that will supply the needed alternatives and the framework for their realizaion. We shall have to explore not only our institutions and procedures, but the images and values on which they rest.

But already the decade of dialogue has begun: Zero growth, Intermediate technology, sustainable harvesting,... We read the dialog in books such as Erich Jantsch's, DESIGN FOR EVOLUT I ON, Ervin Laszlo's STRATEGY FOR THE FUTURE. We hear the dialog at meetings of the World Future Society where a prominent senator says, "Those who actively engage the future are the ones empowered to shape it". And we participate in the dialog in meetings such as the one today. I feel it reasonable to say that this searching dialog of ouir times has grown up with and is centered around what is called the futures movement or futures research or futuristics, whichever name you prefer.

While the new world view has not emerged--and.it won't over night--already we are realizing useful modifications in our approaches to problem formulation and solving, to the treatment of values, to our priorities and decision making processes, and to the importance. of assessments made in advance allowing us to discard the dictum-that' universally governs the behavior of little boys: *If we can do a thing, we must do it.* But Perhaps the most O'sbekian Law uncomfortable identification emerging from the dialog is the increasing suspicion that it is the Scientific World View that is playing the role of the crown. At this point I expect to hear cries of 'treason' from the back of the room. But on this issue I am no tory.

This noon, time does not permit us a detailed demonstration of this point of view. We are all familiar with some of the conventional attacks made against science by Roszak, the hippies and the neoluddites.

But the futurists' difficulties are referenced in Boulding's statement, "All scientific knowledge is about the past, all. decisions are about the future." If we assume the past to be the.best guide to the future, and this is our usual assumption, then we cannot escape from the past and we will keep reliving it. Today's futurist holds that the past is a poor guide to the future. This in no way is meant to imply that scientific knowledge is not valid, but it does mean that the assumption that the universal application of causal determinism, the foundation of so much of scientific modeling, is not the best vehicle to project us into a really new future.

Knowledge is based on facts and what is important about facts is whether they are valid--true. and science has been very success ful in developing methods for validifylng factual knowledge. But decisions, while based on facts, are also based on other things such as values and goals, and these are not true or false, they are desirable, useful, workable, beautiful, meaningful or other things lying beyond the canons of scientific testability.

This will have to suffice as an indication that futures research must move out beyond the methods and techniques useful to science and develop a suitable epistemology to handle its own requirements.

There is one subject, however, that science and futures-research share in their respective domains: This subject is the nature of change. Change is basic to phenomena that are repeatable and ubiquitous, objective and value free, that is, those phenomena treated by science; and change is basic to those experiences having to do with images, values goals and decisions, all admittedly subjective and value ridden, the area treated by futures research.

And it is in the exploration of the nature of change that we encounter deeper difficulties with the Weltanschauung of Science for the purposes of Futures Research. The futurist requires a different model of change and a different model of time than that which has successfully served the classical sciences. And in the study of change we are led to novel candidate ideas for the emerging world view.

Historically, there have been two polarized views of the essential nature of change. The first of these views has its scientific expression in !he words of Laplace (Young P 305)

> "Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective situation of the beings who compose it--an intelligence sufficiently vast to submit these data to ahalysis--it would embrace in the same formula the movements of the greatest bodies of the universe and those of the lightest atom; for it nothing would be uncertain and the future as the past would be present to its eyes."

This view also has a religious expression in the poem:
"What the first Morning of Creation Wrote, the Last Dawn of Reckoning shall read."

This view of change based on causal determinism or one of its modifications is the philosophical base of scientific prediction and of any brand of prophesy that can foretell the future (note in this philosophy future is singular). We may designate this tradition, and it is an ancient one that includes fatalism, predestination, etc, that of the prophet.

At this point I would like to introduce a metaphor, suitable perhaps for illustrations in an after luncheon talk but not for the dialog proper.

Let us think of all human experience as pre-written in a book. We are the readers of the book. Right now we are beginning to read on page 1976 of the latest volume. Pages already read and turned we call history, up-coming pages we call <u>the</u> future. The place where we are reading is called the present. From time to time there appears an individual with rare gifts who is able to read what is written on the yet unturned pages. He is called a prophet. But the prophet is not to be confused with the maker of scientific predictions who deduces what will be on the next page from what he is reading in the present. His deductions usually are based on analogy with similar sequences that have repeatedly occurred on previous pages. It is essential to his function, however, that the book be already written and that we be readers, for otherwise there could not be scientific law.

But there is a second equally important classical theory of change. In the terminology of our metaphor of the book, human experience is again written in the book, but is not pre-written, It is written as it happens and it is we who are the authors. The pages already turned are those on which we have written the record of history. The place where we are writing is the present and the future consists of all of the unturned pages which are blank and upon which we shall be free to write as we please.

This tradition is also an ancient one. It is the tradition of the planner. It built the pyramids, laid out the streets of Persopolis, constructed all the roads that led to Rome. This tradition is very much alive in the world today. It is the view of the existentialist who believes we are free to reshape the world completely at every instant of time. It is the view of those who made it possible for man to place his footprint on the moon.

As I said these two views of the nature of change are polar extremes and in recent years only occasionally does someone present a case for the out and out adoption of one view and the discard of the other. Scientists, such as Rensch in his recent book *Biophilosophy,* still hold for a totally deterministic universe. Humanists, such as Sartre, hold for a total freedom view. To account for all experience we must live with both the view of the prophet and the view of the planner. Science to form its predictive models must employ causalism: the past shaping the future. Society to plan and build its structures must operate with finalism: vision of the future shaping the present.

This paradox on the nature of change is somewhat like the dilemma which confronted physicists concerning the nature of light. Light behaved in certain experiments like a wave and in other experiments like a particle. Neither view by itself could explain all of the observed properties of light. it was necessary to employ both. Only in the integrative.synthesis of quantum mechanics in the 1920's was this century old dilemma resolved.

The futures research workers in designing the their methodologies and systematizing ways of studying the future have done with determinism/finalism what scientists did with the particle/wave dilemma. For purposes of forecasting, the world system is viewed as deterministic; for purposes of planning the world is viewed as finalistic. But all the while a search has been going on for the analog of quantum mechanics that will enable the contradictions to be integrated.

Returning to our metaphor,.the futurist has come to believe something like the following: First we agree with the planner, we are primarily authors of the book, not just readers. We write in the book at the moment of the present, but as we do so we simultaneously write on the ensuing pages, so the prophet is correct too. There is indeed something fixed to be,read on the pages of the future, but we have written it there ourselves. In today's world as we turn each page we are finding that there is increasingly less blank space per page. Since the primary thrust of futures research is to generate sets of alternative passages from which we may select what we prefer to write in the book, it becomes a meaningless endeavor unless there is sufficient blank space for the inscription. The futurist recognizes this problem by stating that, while it is true that the next five or so pages are pretty well filled, there is ample blank space on the pages beyond. (But after 20 or so pages there is little or nothing for the prophet to read.) But this rough statement is barely more than an admission that this central problem exists.

These are times characterized by rapid change. We are writing more and more on each page as we go. and we are also simultaneously writing more and more on the pages of the future. Whether the amount written on the future pages depends in some necessary way on the amount we write on the present page--i.e. on our rate of change--is not clear. But if this is so then the planner will find himself increasingly uncertain and frustrated and with less and less freedom in planning. Only the role of the prophet will remain. He will stay in business to tell us what we have inadvertantly filled in on the pages of the future.

What we are talking about here is the phenomenon of slow or delayed feedback. The pollution that we have been writing for decades before it impacted our perception: The theft of our cities by the automobile; the increasing shortage of rewarding work and diminished access to the market place; the loss of meaningful social roles and a general crisis over the loss of purpose in life. All the unplanned consequences of our many plans.

We have come to recognize the necessity of comprehensive planning. Yet in this country we fear such planning because we see in it a threat to our freedom and a challenge to the survival of democratic institutions. The dilemma has been posed: We shall face chaos and eventually collapse if we do not begin to plan comprehensively, but in order to do total planning we must coordinate and centralize all planning as is done in Communist Bloc countries. But this is not the only choice open to us. Our society moves in the direction statistically determined by the interactions and cross impacts of all of the many microplans developed by each center of enterprise. free market of plans

Soviet society moves in the direction dictated by a central planning bureau. While it is easier to study the dynamics of a single particle than that of a statistical ensemble, this is not the issue, for the mathematics and the programs for the study of predicting the behavior of statistical systems exist. The problem resides in the nature of the microplans. We can get the macrosystem to go where we want it to go with out a dictatorial politbureau if we can orient the microplans correctly. And the key to the microplan is the microplanner.

With the new consciousness that the futurist has catalyzed, we are beginning to consider not only the alternate passages that we may write in the book, but to study how the process of writing itself works and how it may be changed so as to better control the inscriptions that we are making on the pages of the future. This is indeed a new approach to change and it is sufficiently different from the historic approaches of the prophet and the planner to warrant a separate designation: Why not call it the approach of the futurist?

So we are now thinking about *how* we write as well as *what* we write. Your conference here is a study of how we write as well as what we write. But basically to change how we write we must change ourselves, the writers. We must recognize the planner as being part of the plan. Indeed he is the most important part of the process. In the future the dynamic of change must take into account the changing planner.

The planner of the future will not only be a planner who can take into account the changing context in which he does his planning, who can plan holistically, tracing the impacts and side effects of his plans to their fifth cousins, but be a planner who in seeing himself as part of the process can continually redesign himself.

The striving for objectivity was an important compass during the centuries of unconsciousness. But in an age of increasing consciousness we must no longer artificially keep the subject and the object, the planner and the plan, the knower and the known in separate boxes.

We are moving toward the level in which the guideance of change will become primarily the guideance of change in the changer. Self reference now enters our metaphor. There must be change in the author of the book as well as in how and what he writes. We now take on the responsibility for our own evolution.
And after we have succeeded in doing this, we shall make the final discovery: The writer and the book in which he writes have become one. But then they have always been one. But it was a necessary part of our journey to consciousness to first separate and objectify before we could perceive the whole.

Notes: Test for Validity   Epistemological mis

DRAFT: 4 January 1963

To confuse all of us further - all of us living in an age of crises, under the sword of Damocles, at a disjunction point in history - we find not only great divergence in opinion on how to proceed, but also basic divergence on evaluations of the present state of the world, including argument on each of the above premises:

Does or does not a disjunction exist

Is or is not a nuclear war catastrophic

Is or is not war obsolete

Unified action on any front -- whether it be for example to build shelters -- as adovocated by one camp or the move toward abolition of war, as advocated by the other camp is forstalled by violent disagreement on the fundamental premises concerning the real nature of the threats, risks, and consequences of war.

Supplementing this gulf of opinion is the strength of conviction of those holding the opposite points of view -- the incredibility that possesses them at the naivity or obstinancy or stupidity or maliciousness of anyone who could hold the opposite view.

This is a chasm of thinking within our own country and the West as deep profound and as broad as the chasm separating the thought of East and West. Both are characteristic of men who possess no method of proving or testing teir opinions or at least who cannot agree on what constitutes a proof, a valid argumnet, or a validifying test. In my opinion, there is no hope or even use in arguing further about Communisism versus Westernism of Kahnan-Nuclearism versus the New Pacifism until the more fundamental question of how does one establish the validity of a prin iple or hypothesis in economics, untested milityar theory, psychological reactions to vast destruction, new social and political situations as created by new esapons and new technology.

Agreement has been accepted as a measure of validity, and at some level this is the ultimate measure. The objectivity is measured by the level at which agreement is sought. We have for example, that the validity or invalidity of proposition A is established by agreement - consensus or we have that the validity of proposition A can be established by certain test, experiment or reasoning from a model, etc. But agreement comes in here on which of any of these second order processes is accepted as itself valid for showing validity of first order propositions. Science is nothing more than consensus on second order propositions for the establishment of the validity of first order propositions.

What is now required - now that we are in an area of disagreement on second order propositions - is some third order criteria by which we may decide which second order propositions are valid -- but again agreement and consensus is the final arbiter. There must be agreement on the criteria by which we establish the validity of processes for testing the truth or falsity of hypotheses before we can rpoceed.

I am persuaded that we must enter the problem on this level before further discussion of unilateralism, coesitence, or any second or first order proposition can be useful.

Direct experience has the support of almost everyone as a test of the validity of hypotheses. One way to test whether Kahn and Teller are right, or their opponents are right, about the consequence of a nuclear war is to have a nuclear war, but then, it might be argued that there are many types and degrees of nuclear war and to understand the picture completely -- we must have one of each type. But the use of the earth as a laboratory to prove who is right or wrong does not have consensus.

Science has found methods on which there is agreement -- which are acceptable substitutes for the real thing -- controlled laboratory experiment - mathematical modeling, etc. Part of the present difficulty arises in questioning the validity of the hiehereto acceptable procedures in new situations involving humand and social situations. This again takes us into our central problem of how to judge the validity of second order processes.

Kruschev has proposed a second order process for testing which ~~xxx~~ political-economic system, Communism or Western Capitalism is more successful in meeting the needs of humanity. This is one aspect of coexistence. Let us consider the USSR and the USA as two vast laboratories to test these two systems. Kruschev's proposeal has not been generally accepted for lack of agreement on the third order criteria by which to discuss it.

With hot arguments waging on first and second order propositions is there hope of getting anywhere on the third level?

Theorem: the rectitude of a proposition of any order is not establishable in the same order

Godel?

War is a first order process -- it cannot establish the validity of first order questions -- it can make decisions, true, but not establish validity. How does this relate to the proposition made above on first order experience?

What can validity be said about the real world on the basis of the abstractions of second order and higher processes?

The three types of dissagreement

1. Between interests

2. Lack of communication

3. The foregoing Russell-Godel problem

Agreement ~~XXXXXXXX~~ fills in the Godel Gap

Example: constants problem,

science

Uncorrected ~~OK to cut/paste~~

A. G. Wilson
12/7/67

TRAFFIC DENSITY AND SYNAPSE DENSITY

It is suspected that there exists a bound to the ratio of the traffic density in the neighborhood of a synapse to the mean spatial density of the synapses themselves. Such a bound appears as the possible explanation of Zipf's Law and the Scott Effect, relating the brightest star in a galaxy to the number of members of the galaxy.

We shall assume a spherical aggregate of N spherical synapses, each of mass M and radius A. The radius of the aggregate will be taken as R. The mean spatial density of synapses will be

$$(1) \quad \bar{\rho} = \frac{3NM}{4\pi R^3}$$

There is assumed to exist a flow of traffic into or out of each synapse. This traffic may take the form of mass particles, energy packets, information packets, or field effects. For example, if the synapse is a city, the traffic may be aircraft, motor vehicles, or telephone messages. If the synapse is a star, the traffic may be material particles (protons, electrons.....), photons, neutrinos, or gravitons. If the synapse is neural, the traffic may be nerve impulses. This traffic is channeled by the nature of the nexus which connects the various synapses. For a city, the nexuses may be the highways, the rail lines, or the air routes leading into the city. In the nervous system the nexuses are the nerves themselves. For a star, the nexus is the field space surrounding the star. This may be ordinary Euclidean space with the nexus permitting a 4π solid angle or it may have more restrictive geometric and topological properties.

I. 4π Nexus

Let us assume that the energy packets may be represented by equivalent masses m. The flux F of these packets will be proportional to the number n crossing a surface of radius r in time T. If v is the velocity of the packets at the surface r, then the energy flux per unit time per unit area will be,

$$(2)\quad F = \frac{n(mv^2)}{4\pi r^2 T}, \qquad [F] = \left[\frac{M}{R^3}\right]$$

From Equations (1) and (2) the ratio γ of the traffic density F to the synapse density ρ is

$$(3)\quad \gamma = \frac{F}{\rho} = \frac{n}{3N}\,\frac{m}{M}\,\frac{R^3}{r^2}\,\frac{v^2}{T} \quad \text{with } [r] = \left[\frac{L^3}{T^3}\right]$$

i.e., the dimensionality of the density ratios is that of a velocity cubed. This dimensionality is bounded in relativistic physics by the quantity c. We therefore assume (4) $\gamma \leq c^3$.

Example:

The traffic is the radiation leaving a star. In this case the energy packet mv^2 becomes $h\nu$. Substituting in (3)

$$\gamma = \frac{nh\nu R^3}{3NMr^2T}$$

But the bolometric luminosity of a star, $L = nh\nu/T$, i.e., the total energy per unit time (take $T = 1$ sec.), hence

$$\gamma = \frac{L}{3NM}\frac{R^3}{r^2}$$

But r is arbitrary so long as $r \geq A$. We may, therefore, take r as equal to A.

For a star $\frac{GM}{c\ A} < 1/2$. Thus setting $r = A$, we obtain

$$\frac{2}{3}\frac{GL}{c^2N}\left(\frac{R^3}{A}\right) < \gamma < c^3$$

or

$$(5) \quad L < \frac{3}{2} N \left(\frac{A}{R}\right)^3 \frac{c^5}{G}$$

The expression (5) says that the energy emitted per unit time is less than a constant times the ratio of the volume occupied by the synapses when close packed to the volume actually occupied.

The maximum value of the bound is when the synapses are close packed. In this case we get the maximum luminosity, $\hat{L}$,

$$(6) \quad \hat{L} < \frac{3}{2}\frac{c^5}{G}$$

The right member of expression (5) can be evaluated. Assume the following values:

$\log N = 11.6$

$\log A = 10.84$

$\log R = 21.8$

$\log c = 10.48$

$\log G = -7.16$

Giving $\log L < 38.46$ ergs/sec.

Using the relation,

$$M_{bol} = M_{bol\,\odot} - 2.5 \log (L/L_\odot)$$

with $\log L_\odot = 33.59$ and $M_{bol\,\odot} = 4.72$

(3.90×10^{33} erg/sec) Allen p. 161

$$M_{bol} = -7.45$$

The maximum absolute magnitude of galactic novae ~~is~~ has been observed to be:

$M_{pg} \sim -7.5$ (Allen p. 214)

(using $\log L_\odot = 33.59$ and $M_B = 5.41$)

$$M_B = -6.76$$

Hence the bound given by the assumption (4) is in excellent agreement with the maximum value of absolute nagnitude observed in the galaxy. (Super giant stars have $M_{pg} = -6.8$.) Supernovae will be discussed separately.

It is of interest to evaluate the maximum possible luminosity of a radiating object under the assumption (4). This may be done in equation (6). Using the same values as before, we obtain

$$\log \hat{L} < 59.74 \text{ ergs/sec}$$

This is essentially the power value for quasars, according to the cosmic distance hypothesis (Hoyle and Fowler). We thus have as a consistent interpretation of equation (6), that whenever a set of stars are close packed (or one star not a member of any aggregate), that the luminosity can be a maximum and has the value $10^{59.74}$ ergs/sec. This does not permit the mass of the quasar to be derived, but it suggests that quasars may possess a wide range of masses all having essentially the same luminosities. It is accordingly their <u>lifetimes</u> that vary with mass not their luminosities.

Equation (6) may alternately be derived by setting $r = R$, the radius of a galaxy, and using

$$\frac{GNM}{c^2 R} < 1/2$$

which gives (6). This would lead to the conclusion that quasars are ~ galactic mass.

Let us evaluate L in equation (5) under the same conditions of N, R, etc., but assume that A, the stellar radius is that of a giant star instead of a main sequence star, i.e., log A ~ $10^{13.2}$ cm

	$R_{\odot}$	cm
ζ Aur	190	$10^{13.12}$ cm
32 Cyg	353	$10^{13.37}$ cm

From equation (5) we get

$$L < 10^{45.5} \text{ ergs/sec}$$

or

$$M_{bol} \sim -24 \text{ or } -25$$

This corresponds approximately to the luminosities of <u>supernovae</u>. (The values of N and R sould be selected for other galaxies.) It thus appears that supernovae correspond to giant stars and novae to main sequence stars under assumption (4).

Equation (5) shows that for a fixed type of star (A fixed), that the maximum luminosity depends on the <u>density</u> of the galaxy in which it is located, such that the greater the density the brighter the maximum. However, since $2GM \sim c^2R$, the mass increases with R not with R^3. Hence for a given type star, i.e., A, M fixed, $\frac{N}{R^3} \sim \frac{1}{R^2}$. Hence the bigger the galaxies the <u>less</u> luminious their giants. This is consistent with the maximum population II stars being fainter than the population I stars and the elliptical galaxies being more massive than spirals.

A. G. Wilson, 1/29/69

LIMITATIONS OF THE SCIENTIFIC METHOD

Out intellects have always been confronted with phenomena and occurrences that cannot be explained. With the growth of the body of organized knowledge, that is, scientific knowledge, old and new phenomena are increasingly being explained in shorter time and without resorting to the introduction of any radically new basic principles. But it is also becoming apparent that certain sectors of experience are barely yielding to explanation through traditional scientific approaches. This fact can be easily put aside by saying that we do not know enough yet to explain certain types of phenomena. Assuming that the progress of science along tractable routes will in time lead us to laws and relationships, we will be allowed eventually to clear up many of our present and old puzzles. But this is not the whole story. Certain sectors are not being postponed, they are being denied. Ridicule of a phenomenon ofttimes replaces the recording of useful data about that phenomenon. One has only to review the Condon report for many examples. Another example is the recent redshift quantization results of G. Burbidge.

Scientists, like most people in this culture, are interested in success. They attack the problems for which there is good promise of solution. In fact, part of the definition of a good scientist is a man who knows what problems to work on.

But on closer examination, this means those problems most likely to be readily tractable, not necessarily the problems of greatest import, or the problems most in need of solution. Perhaps the giggles encountered at the mention of UFO's, for example, at a scientific meeting are a psychological reaction to some sense of guilt that is coursing through scientists; at some level of consciousness they are undoubtedly aware of this defect in their approach to knowledge.

A. G.Wilson, 1/29/69

THE TOLSTOY EFFECT

Whenever factual material or observations must be made concerning the sense experience of single individuals or large groups of people who have not been especially prepared to focus on the observations, an effect which we will call the Tolstoy effect occurs. This is the sort of problem that arises in the case of a highway accident when the witnesses are suddenly focussing their attention on a happening which they were not expecting. In order to put their observations into an organized form the witnesses are interviewed and a story is pieced together, but the story that is pieced together is rarely consistent.

also for Experience outside that permitted by Worldview => need for interpretation, explanation

This is how Tolstoy explains the situation, "Visit all the troops immediately after a battle or even on the second or third day afterwards, before any reports are written, and ask all soldiers, the lower and higher officers, what happened. All these people will tell you what they experienced and saw and you will get a high-flown,confused, endlessly varied, unclear impression, and from no one, not even from the commander-in-chief, will you learn what really took place. But in two or three days reports are presented. Wagging tongues begin to relate what happened, what they didn't see. Finally a general report is put together and from this report, the army forms a general impression. Everyone is relieved to have his doubts and questions

Reference?

supplanted by this untrue, yet defining, picture. Within a month or two ask a person who lived through the battle about it and from his description you no longer will feel that unvarnished live material is being presented. He will sound like the official reports to all intents and purposes."

Perhaps the assassination of John F. Kennedy is a star example of this type of procedure. We are willing to settle for a report that is untrue in order to put to rest the terrible tension of the uncertainties that becloud a very complex occurrence. It is this willingness to settle for a simplified authoritative version rather than to continue to encounter the troublesome, confusing, inconsistent facts that leads us not only in experiences confronting the historian, but in situations frequently confronting the scientist to adopt a methodology of authoritarianism.

A. G. Wilson, 1/30/69

EPISTEMOLOGY

The process of knowing is at root the process of recognition. It is thus akin to recollection. In order for an event or phenomenon to be knowable, it must already exist in the "memory." And by "memory" is meant something more basic and comprehensive than ordinary memory. Just as the total information requisite to construct the entire organism resides in every cell of the organism, so in every intelligence reside the set of patterns which are matchable with the patterns of sense experience. Whenever a pattern from sense experience matches an "a priori" pattern, it is recognized and then becomes known. The domain of the knowable is pre-set in the storage banks of the intellect. No pattern which is not so pre-set is recognizable and is therefore not directly knowable.

Under this epistemological model, we neither discover nor invent, we recognize. Synthetic a priori statements thus are not only possible, but become the only propositions possible. However, until a "critical mass" of recognitions have been accumulated the nature of this identification is itself unknown. At the present time we stimulate into awareness mostly through the processes of sense experience. We conjure up patterns in the sense world and parade these before the consciousness. Whenever a matching occurs between a pattern of the senses and an a priori pattern a recognition is effected and a new piece of knowledge born.

A. G. Wilson, 1/30/69

THE DETECTION OF LIMITS

One of the most fruitful objectives is to determine the limitations that the natural order imposes on the possibilities of structure. It is extremely useful to find that a certain phenomenon can occur only in a certain way. The earliest example of this was the discovery by the Pythagorians of the existence of the five regular polyhedra. Although four of these were probably known before the Pythagorian academy was established at Cratona, the discovery of the dodecahedron is attributed to Pythagoras himself. The fact that only five such polyhedra were possible made a tremendous impact on the thinking of the Greeks. It has been said that all of Euclid's geometry was designed in order to demonstrate the laws of geometry that showed the impossibility of more regular polyhedra. Today, we have other examples, though none proven in the way of this geometric example. We have in physics a limiting velocity, the velocity of electromagnetic propagation. We have in the theory of relativity a limiting value for the gravitational potential given by the Schwarzchild solutions to the equations of general relativity. When we have detected a limit or boundary beyond which we cannot go, we begin to get a feeling of real knowledge concerning the world.

An ancillary methodology associated with the detection of limits is the detection of limits through the possibilities that exist in design. It seems rather backwards to study the natural order through design when we have for centuries been using findings of the natural order in order to create techniques of design. However, we find that certain of our creations produce objects worth studying just as we study the natural order. We have, for example, freeways. There does not exist in nature a fluid having the properties of the traffic, which is a fluid flowing along the freeway.

This approach also may throw a great deal of light on why we observe the particular entities which are found in the natural order. This is because those which remain in the natural order have been there a long time and are, therefore, stable. Many other systems at various scales could have existed initially, but have been unstable and have long since ceased to exist. In putting new systems in unstable regions, we will learn something about stability and possibly, the origin of the natural order.

One more aspect of the use of design for studying the natural order should be mentioned. This has to do with what we mean by understanding. We say we understand a phenomenon or an event when we have reduced it to an everyday occurrence, when we can show the relation between a complex event and commonsense or everyday experience, then we say we can understand it. The base of our understanding is our everyday experience. It is the realm of familiarity. In creating new complex objects, such as freeways, and observing the flow of traffic on the freeways, we are not only creating a new system at a new scale point in nature, but we are extending our base for understanding. We are extending the base of familiarity and hence, our epistemological attack moves forward on two fronts.

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We shall take explanation to mean the creation of a symbolic structure that links together a new phenomenon or event to the known structure which is the body of knowledge. We shall take understanding to mean the reduction of structure to a cognitive core that may be called common experience, or everyday experience; that is, the reduction to the familiar.

Thus the growth of knowledge, and by knowledge that which is explained and linked to the central core of knowledge, exceeds the growth of understanding. Scientific experience rose more rapidly than our familiarity increases. Hence, a Nobel prize physicist can say though our equations tell us what is happening, no one can say that he really understands the situation in particle physics.

This leads us to the concept of three distinct frontiers: we have first of all, the most advanced frontier, between the intuitive and speculative and the unknown. The second frontier is our frontier of knowledge that is tied by known processes and relationships to a core of scientific knowledge. The third frontier is that between our knowledge and our understanding, or between the regions that can be explained and the familiar. And finally, there may be an innermost core, which is the area that we call wisdom.

A. G. Wilson, 1/30/69

We may divide the variables or parameters that we use in describing the world into two classes: the first of these we may call the observables. These consist of those quantities such as mass, time, distance, velocity, etc., that we are able to observe and measure. The second class of parameter we might call an optimum descriptor, or simply a descriptor. A descriptor is a variable which enters into an equation or a relationship in a very simple manner. It is what some authors have called a function variable and it provides the simplest description mathematically relating observables or other function variables. We have, for example, in mechanics the LaGrangian and Hamiltonian functions as the descriptors most useful for a simple representation of the laws of mechanics, whereas the Newtonian formulation using ordinary observables is much more cumbersome. The reason that we have theories is because the set of variables that we observe is not always the set of variables providing the simplest relational explanations of the world.

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THE TWO EPISTEMOLOGIES

We may divide the approaches into exploring the unknown into two classes that we appropriately may designate as <u>theory directed epistemology</u> and <u>undirected epistemology</u>. Theory directed epistemology becomes possible only when a critical mass of basic propositions have been accumulated and validated. It becomes possible when there are sufficient well established theories to make good predictions concerning phenomena not yet detected or observed. A critical mass of theory not only allows an explanation of all observed phenomenon but provides a good direction in which to explore the unknown. However, a critical mass, while able to guide us in asking the right questions and seeking the right frontiers to new phenomena, may not be the same as a definitive mass of theory that can relegate observation and experiment purely to the realm of checking on the predictions of theory. We certainly have a critical mass of theory available to us today, but we do not have a definitive mass, and I doubt that we ever shall. This means that we still have to allow for our second epistemology, our undirected epistemology, or our search for new phenomena. Now our search can be systematic and can be structured along the lines of exhaustive observation and this will lead us to a formulation of an optimum strategy for exhaustive observation using a concept we shall call cognition space. We will return to that later. But a principal guide in the search for new phenomena is to search for the strange, to search for the paradoxical. Finemann said that the great discoveries in science have come from taking a good hard look at existing paradoxes.

The second epistemology, the search approach, is predicated on the idea that there exist classes of phenomena that lie outside the basis of our existing theory and will not be detected at all from theory directed research, since these phenomena are not implicit in the theory. We have, for example, the recent discovery in astronomy of quasars and of pulsars. These objects were contained in no theory and had theory alone guided our observational programs, we would not have encountered quasars and pulsars. We are still being guided by the search for the paradox, the unusual.

Perhaps it is important to point out that computer simulation is a special case of theory directed epistemology, and though we may be able to derive from computer simulation many predictions too complex to have derived directly from simple analytic manipulation of theory, it is still subject to the limitation that nothing is going to come out of the simulation that did not go into it. A computer simulation program is not going to discover a quasar or a pulsar by putting in prediscovery astronomical theories.

In approaching the subject of space exploration and the basic argument of manned versus unmanned exploration, we find that the use of a man is primarily to detect the strange or to spot the paradox, that which is inconsistent or appears to contradict known knowledge, or is not contained in present theories. Unmanned exploration could completely replace manned exploration for epistemological purposes, and exploration is primarily for epistemological purposes, if we build a system which could be designed primarily to spot the paradoxes, to focus on the strange. Man can spot strangeness because he stores in himself his theories and his contingence (?) of known phenomena. Is it possible for an artificial exploration system to be designed to spot the strange without having in it a memory of known theories and phenomena? A certain amount of experience is necessary to know what is really strange. A small child is awed by everything in his experience and he would not know what is strange in an epistemological sense.

We may then define the "epistemological game" as the process of applying theories, that is, known propositions, to the explanation of phenomena. We have a win when successful predictions are made. An important aspect of the game is what we might call "the definitiveness index". When the number of observational synapses is small the number of theories possible to account for the observations may be quite large. This is the present case in cosmology and in astronomy in general. A unique theory may be isolatable. Of course, it may true that a unique theory is never isolatable. However, when a number of observational synapses is very large, it may be difficult or impossible to give even one theory.

The emergence of a paradox becomes one of the most important events in an epistemological growth. Which of the two epistemologies, theory directed or undirected, that is, strangeness search, should be employed at any time depends on the definitiveness index. An epistemological region which is tight, that is, well understood, will grow readily by theory directed research, and the probably of uncovering the paradox is small. An epistemological region which is not well understood may grow more rapidly through undirected search, but in either event, the highest priority should go to the strategy that would to the uncovering of paradoxes.

We may then summarize some rules for the epistemological game:

(1) We should search for new phenomena when the definitiveness index is small.

(2) We should be guided by theory largely when the definitiveness index is large.

(3) Whenever possible, a paradox should be given the highest priority.

EPISTEMOLOGY
SPACE EXPLORATION

January, 1967

PROBLEMS THAT ENTER THE DECISIONS OF WHAT OBSERVATIONS TO MAKE-WHAT DISCRIMINATIONS TO MAKE

There must be some balance between making finer and finer differentiations (a finer slice) and pulling the pieces back together into a whole view. Usually in any situation of application, this balance between differentiating and synthesizing is demanded because resources are limited and it is not possible to make all discriminations or observations and measurements. In addition to economic constraints, there are other limitations in delineating what is knowable of the universe through astronomical observational techniques. Basically, these limits derive from a mixture of the inherent limits of any one instrument as well as the location from which this instrument is used. It is not always possible to separate these constraints by looking at the historical development of astronomical instrumentation since the very real limitation imposed on observational techniques by ground-based astronomy was a chief factor dictating the design of instruments. Thus the historical development of instrumentation contains many subtle and exotic techniques to overcome difficulties such as earth atmospheric transmission that may or may not be necessary for observations made at other locations than the earth's surface. We will therefore find it useful in formulating criteria for deciding what observations to make to include some quantity that designates location of the observer.

Another limitation that enters our main decision of what observations to make is the one of how many times and over what period shall we observe an object or event. In seeking to understand phenomena that change in time and/or direction, we need a measure of how well our observation matches the object or event observed in both duration and frequency. Changes in magnification or field of view introduced by "bigger and better" telescopes may not detect phenomena that are characteristically periodic such as Sun Spot cycles or Martian blue clearing. In order to detect change it is necessary to preserve a baseline. The assumption implicit in any exchange of information (which is what an observation is) is that there exists a receiver. The requirement on the receiver is that it is capable of reacting in such a way as to maintain its own stability whenever a change occurs. How then, will we measure coverage of the object or event we want to observe? I can think of only two basic approaches to this problem of matching the range of observation with the duration of object/event:

1) to try to characterize the phenomena to be monitored,

or

2) to systematically survey over all ranges in both time and space.

The candidate objects/events to be studied each provide different levels of existing knowledge. For those objects or events that we can already characterize, we can match our network of observation and for those that are less known we must begin with systematically surveying in time and in space. Hence we cannot expect to impose an equal level of effort on all objects. But a measure of current knowledge will be useful in making decisions of what observations to make since the level of effort required is a function of what we already know.

The problem of tracing how the results of any one observation-measurement feed into the main questions we want answered is similar to the problem of retrieving relevant information from a library. Our quest is to retrieve answers to specific questions such as how the universe originated; how the universe reached its present configuration; what factors are now at work in shaping its future; or what forces combine to foster the emergence of life. But just as the librarian must help structure the user's request for information from a library by asking how much information do you want, what use do you plan to make of it, how soon do you need it, etc., in order to fulfill the request, we need to structure the steps required in translating the requirement into the observables that are possible. This translation is not obvious; yet the need to decide what observations to make requires that we can display some idea of the relevancy of any one observation-measurement to the big question. So far as I know, no one yet knows how to measure relevancy. Evidently, it is not an absolute quantity. One can think of extremes that satisfy any one library request: the user's request could be fulfilled by giving him the whole library - or by giving him one document. Neither limit is satisfying. It is necessary to find some way of designating how relevant.

Relevancy tells us how things are related. In a science as complex as astronomy, the logic networks connecting observations-measurements are not always delineated in an obvious way. The question of where to find the inherent structure that displays how observations-measurements are related to the big questions suggests looking at existing observational methods and trying to trace their relationship to the big questions.

This type of systematic analysis to reduce proposed observations-measurements to basic operations is one way to see relationships between specific proposals. How any one observation ties into a big question requires that we reduce the questions to basic knowledge requirements that can be matched with these available observational operations. The relevancy factor we desire can then be formulated as some function of how well the available observational operations match the requirements.

In addition to showing relevancy - it may be that another factor we can call complexity enters the main decision of what observations shall we make. The idea that certain observations or measurements are less complex or difficult than other observations seems intuitively possible but how is it possible to measure complexity? Obviously if the things we were attempting to classify fell into neat simple piles, the problem of complexity would not enter in. The underlying common idea in any attempt to organize objects is that the elements belonging to one set are more highly related to one another than they are to non-members. It is obviously more complicated to establish classifications based on many characteristics than it is to establish classifications based on only one characteristic. None-the-less, one measurement may contribute to several knowledge requirements and we cannot force the structure into a logic network that insists on only one path to a higher level. The idea of complexity is illustrated by the differences displayed in connecting sets as trees or as lattices - the tree structure, although admittedly more simple than the lattice structure, does not admit any choice in the path from a lower level to a higher level. Thus it is simpler but not flexible. The analogy in astronomy might be that we insist that any one set of observations/measurements designed to match a specific knowledge requirement of a big question not be used in any other knowledge requirement. Obviously this mandate would add much duplication and redundacy of effort. Even though we introduce a certain amount of complexity in trying to include all the connections between elements that overlap, it may be possible to obtain a measure of complexity by doing this. The suggestion is that complexity ~~is that complexity~~ is related to the order of choices in the paths connecting observations/measurements to known requirements and this criteria bears on the final decision of what observations to make.

For any one proposal:

<u>where:</u> earth, moon, orbit, fly-by

<u>how long and how often</u> (epoch)

time and space -

f(existing knowledge)

<u>how relevant</u> - to big question

f( )

<u>how complex</u> - many connections or few

OUTLINE: METHODOLOGY BOOK - A/D. Wilson   Draft: Oct. 1967

1. PROBLEMS

   1.1 What is a problem, a question, an explanation, understanding, etc.

   PHILOSOPHICAL MODEL

   1.2 Can we resolve sets of problems -- decomposition and structures of problems?

   TAXONOMY OF PROBLEMS

   1.3 How do we select what problems we work on?

   PROBLEM SELECTION

2. STRUCTURE

   2.1 General description -- phenomenology.

   FORM/CONTENT/CONTEXT

   2.2 Grouping, ranking, mapping, isomorphic -- homeographic, horizontal vs. vertical mappings (e.g., an outline is a tree: a set of groupings with rankings).

   STRUCTURING OPERATIONS

   2.3 How can we measure the amount of structure? Information measures amount of structure in simple types of system only.

   BEYOND INFORMATION

   2.4 Relation between probability/information/structure.

      2.4.1 Sequence from statistical fluctuations to existence of an entity.

      2.4.2 Definition of random versus existence of entity.

3. ABSTRACTION

   3.1 Inventory of types of abstraction

      3.1.1 Nesting (hierarchical)

3.1.2 Reductionist

3.1.3 Subset (e.g., geometrical, communality, etc.)

3.1.4 Symbolizing process of psyche

4. HIERARCHICAL

4.1 Establish framework for other discussion

4.2 Sequence of containments:

Sometimes tendency principle

Sometimes conservation principle

5. STRUCTURE/BEHAVIOR

5.1 Analytical: e.g., reductionist

5.2 Correlative: operating within same level

5.3 Teleological: within and between hierarchical levels of organization

6. RELATIONSHIPS

6.1 On same level - correlative types

6.2 Between levels - hierarchical

6.3 Do macro-effects derive from probabilistic micro-effects? Is there an inverse of probability? Teleos moves from upper to lower.

PROBABILISTIC VERSUS TELEOLOGICAL

7. DATA DISPLAY

7.1 An operation for changing parameters or discovering new parameters.

7.1.1 Find incongruities - blows the system.

7.1.2 Paridigmatic inference - reinforce suggested patterns.

7.2 Mechanical aids

7.2.1 Fouier transformations

7.2.2 Standard regions

7.2.3 Super-positions

7.2.4 Correcting IOD feedback

7.2.5 Archetypal experience (LSD)

8. THE NEW METHODOLOGIES

8.1 Optimization methods utilizing teleological categories.

8.2 Show method is form - not content (e.g., cost-effectiveness is an assumption about value, not a method).

8.3 Methods to treat "natural" versus "man-made" phenomena - Do phenomena breed science?

9. SETS OF METHODOLOGIES

9.1 Scientific method

9.2 Optimization techniques

9.3 Hypothesis generating methods

9.4 Search for limits

9.5 Organization - influence methods

9.6 Departure/return, temporal/spatial, high/low resolution

9.7 Inventory/structure.

10. ENERGY/INFORMATION

10.1 Classification of systems

10.2 Energy/information interface

10.3 Energy/information couplings

10.4 Vertical/horizontal communcation and energetics

11. TENDENCY/CONSERVATION PRINCIPLES

11.1 A sequence of containment - i.e., a tendency principle may contain a conservation principle and vice versa.

11.2 Horizontal/vertical relationships (oblique)

11.2.1 Tuning in on circadian cycles.

11.2.2 A. U. and c.g.s. units ratio

11.2.3 Schwarzchild limit is an oblique relationship

11.3 Is the second law of thermodynamics a vertical or horizontal principle?

12. CONSTANTS

12.1 Horizontal:

12.2 Vertical:

12.3 Oblique and ratios

draft 11/2/67
A/D. Wilson

EPIST.

Section 1.1 WHAT IS A PROBLEM?

Methodologies exist because there are problems to solve. In the largest sense we approach the question of what is a problem by considering its structural context. We ask in anthropomorphic fashion, who is the problem-solver? Following this train of thought, we also ask, who formulates the problem and beyond that, who identifies the need to formulate a problem? Without belaboring this who, let us use these three activities to answer, what is a problem? We recognize three acts in the concept of a problem: 1) we say there exists a problem when we detect an incomplete structure, that is, when we become aware of something missing or something that disrupts the unity of the whole. 2) We formulate the problem when we succeed in establishing a limit or bound around the incomplete structure. For example, when we speak of the problem of underdeveloped countries we define (de-limit) some class of countries. The problem of underdeveloped countries means that something (called underdeveloped countries) is a partial structure - an incompleteness in relationship to a unity (a world that contains at least one other class -- developed countries). Formulation of the problem means to limit (define) the partial structure; to focus on the thing that disrupts the completeness. 3) We solve the problem when we complete the structure and achieve once more the sense of wholeness. Thus, these three activities are structuring acts - structural components in the concept of a problem: identification, formulation, and solution.

Before going on to illustrate these three phases of a problem with specific illustrations, (sec. 1.2) we might also ask what is a question? A question is similar to a problem except in content. Usually, when we speak of questions we deal with the identification, formulation and solution of propositions -- that is, mental constructs rather than physical contents such as energy and matter. We use the word question rather than problem when we deal with information. For example, what is the population of underdeveloped countries? What does the author mean by underdeveloped, etc.,? Questions, like problems, contain three acts: identification, formulation, and solution. For our purposes here, we do not need to differentiate this difference more precisely. We will use the word <u>problem</u> in connection with contents of energy and matter of the physical world and the word <u>question</u> when we deal with propositional or informational contents.

When we consider problem-solution or question-answer, we again find two general kinds of things that satisfy. Sometimes we say we understand; other times we say we now have a clear explanation. By <u>understand</u>, we recognize at least two different levels. On one level, understanding is reached simultaneously upon reaching a level of familiarity, that is, we can now relate the disturbing partial structure to a familiar one. In this sense, the problem (or question) disappears. On a much deeper level, when we speak of the understanding, say, of physics, understanding the nature of the physical, observable universe, or man's understanding of the human psyche, we refer to the limits of our own mental structure. We can go no further at this point -- we have taken the recognizable and familiar to the walls of what is knowable. We can do no more than to anchor our understanding at this point. These walls are similar to Whorf's basic concepts (ref.) or to Jung's idea of a psychoid(ref.).

When we use the word explanation, we mean that we have reduced the examined structure -- the limited partial -- to some accepted whole structure. This requires that we can demonstrate the relevance of our problem-solution to an existing understanding. Mathematicians usually "solve problems" by reducing a problem to one that is already understood. In general, we will use the word explanation when seeking to establish a linkage between an isolated partial entity to a unified, existing whole. The main activity of educators, for example, can be considered as demonstration of linkages between new or isolated experience and the established or accepted structure of human knowledge. We now move on to discuss specific problems and classes of problems.

Section 1.2 DECOMPOSITION OF PROBLEMS

On some level of abstraction, we ask is it possible to recognize patterns in frequently recurring problems? Can we find commonalities in problems that arise in different places? One example available to us comes from the computer experience utilized by business administration operations. Ackoff classified the set of problems found in business administration into eight classes of problems (ref*). These are: inventory, allocation, queing, routing, sequencing, replacement, competition, and search. The value of this decomposition is illustrated by the fact that businesses such as IBM use this set of typical problems in selling their problem-solving capabilities. The IBM success in capturing the computer problem-solving market affirms the value of considering how problems can be classified and decomposed into basic modules. For our discussion of a taxonomy of problems, we are interested in two aspects of this list of eight problems: 1) are these particular classes found in other places (biology, astronomy, etc.), and 2) can these eight be decomposed into more basic modules?

(add more description here from Ackoff's book...)

*Ackoff, R. L., A Manager's Guide to Operations Research, John Wiley and Sons, N. Y., 1963.

In summary, these problems consist of inventory, allocation, queing, routing, sequencing, replacement, competition, and search. We are interested here in whether or not these problems decompose into a smaller number of basic problems -- that is, are there more fundamental modules that go to make up these eight typical problems? Consider the four basic operations of computers utilized in business administration problems. We find that a computer must provide capability for: 1) input-output, 2) memory, 3) logic and control, and 4) arithmetic. This suggests the concepts of form and content. Let us think of form as a box and content as the entities inside a box. The computer capability for input-output means that we need the capability to load boxes and to unload boxes; memory is the capability to store boxes, either empty or full on some combination of full-empty. Logic and control means that we have the capability to give instructions for the operations of loading, unloading or transferring and operating on the entities in boxes. Arithmetic means we have the capability to perform arithmetic operations upon the entities of the boxes. In considering the eight problems above, we note that allocation has to do with distribution of resources. This immediately brings in the concept of optimization. The necessity to allocate results from limited resources. In such a case, we must distribute available resources according to some specified criteria we wish to maximize or minimize -- cost, for example.

In general, we see that several of these problems involve locating a box, transferring a box, and changing the contents of a box, i.e., loading-unloading or operating on the contents. It may be that the basic modules of these problems have to do with operations on form and content. Consider our provious structural description of a problem. We identify a problem by detecting incomplete structure. We did not specify whether the incompleteness was in form or an incompleteness in content. An example of insufficient form is the case where existing classification (such as a file) does not include sufficient categories to catalog existing or known phenomena. The identification of recently discovered astronomical objects called quasars results in a "problem" because the existing forms of astronomical knowledge cannot catalog these objects. An example of incomplete or partial content is the case where content divides or disappears or in some way is modified. This is illustrated in cases where the sum of the known contents does not add up to the whole; that is, where reductional analysis fails to reveal an observed interrelation among contents. Again a problem exists because of partial structure, but here the incompleteness is in (knowledge of the interactions) content. Solution requires completing the structure either by modifying the form or content.

We need now to apply this model of "a problem" to sets of problems in order to discover what problems can be decomposed into basic models. One important philosophical reason for doing this is that there may exist problems that do not decompose into modules that derive from computer operation. There is a danger in considering that all other problems are not interesting or valid. The tendency to treat only those problems that decompose into the IBM basic modules because they are compatible with existing computer techniques may result in neglecting or actually disregarding some set of "problems."

1.3 SELECTION OF PROBLEMS

Can we say anything about how we select problems to solve? The question concerns how we become aware of incomplete structure in the first place. There are various levels on which to discuss this selection process. In the physical world certain "problems" occur in the course of man's interaction with his natural environment. This is the realm from which physical scientists normally draw their problems-to-solve. The history of science records this evolution of "problems-to-solve" such as the motion of planets or the present day problems of quantum mechanics and particle physics.

On another level, problems selected for solution arise from social situations such as war. Since World War II, a large class of problems amenable to the optimization techniques of decision theory, management science operations research, and systems analysis occur from man's interaction with his social world in contrast to the physical world of natural science. In both cases, however, "the problem" is an incomplete or partial structure. Problem-solution requires completing the whole or removing the disunity.

We could go to another level and discuss how the unconscious selects problems-to-solve in the individual or collective realm. According to psychologists, the dream, for example, functions to provide homeostatis in the individual by selecting and displaying certain images to the dreamer. These images make the problem known to the dreamer. The dreamer becomes aware of an incomplete structure in his consciousness if he accepts the dream.

But let us return to the central idea of this section, problem selection. It is possible to map selection of problems-to-solve onto a resource-allocation problem if we let the problems themselves be the elements of the problem-to-solve. In this case we treat the allocation of problems-to-solve similarly to other allocations (such as capital, time, labor, etc.) optimized according to some stated criteria. The questions of priorities immediately arise and this is indeed witnessed today. We are reminded daily of the exponential growth of identified "problems" that occur in the physical realm, the man-made realm and even the unconscious realm. It seems necessary to consider what criteria we will use for selecting which "problems" to solve.

SYSTEMS EPISTEMOLOGY

by

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SYSTEMS EPISTEMOLOGY

The Requirement for a New Epistemology.

The experience of this century has demonstrated in many ways the obsolescence of our ways of filtering and processing knowledge. We nonetheless tend to hold our methods of knowing as basic, unchangeable and absolute-- in somewhat the same way that two centuries ago we endowed Euclidean geometry with absoluteness-- failing to recognize the arbitrariness of some of our epistemological assumptions and values. Specialization and the cellularization of knowledge have generated the requirement for a more comprehensive and integrative approach to our organization of experience to avoid the body of knowledge growing into some new Tower of Babel. Many of the crises we are encountering in the ecology, in population, in resource use and distribution, in human conflict, etc. are now precipitating the recognition that solutions lie beyond politics and jurisprudence. These crises not only have axiological components rooted in historic religious beliefs but also epistemological components rooted in the current world view of Science. Values valid in an age of nomadic migration across the broad plains of an expansive earth--Be fruitful and multiply, Subdue the Earth--are wrong directions for a densely populated finite planet (1). An epistemology that interprets human experience as being an "objective" representation independent of the experiencer is not only delusive but tends to avert considerations of the peculiar powers of the experiencer in interacting with the world. Models and simulations of complex systems, up to the world system, show us that there are failures in our comprehensions.

Complex systems behave "counter-intuitively". Seat of the pants flying does not work for Spaceship Earth. Theobald (2) goes so far as to place the cure for our crises on no less a level than a 'changed way of perceiving reality'. These considerations summarily point toward the timeliness of new value systems, new epistemologies and a new world view.

The current dominant epistemology is the one associated with Science. The precision of definability of this epistemology is not so relevant as its successes in building an extensive and highly reliable fund of knowledge. Though fuzzily formulated this epistemology has been the most successful of all time. However, within the operations of this success intoxicated epistemology there are beginning to be heard some disconcerting signals. The brick by brick edifice of scientific knowledge painstakingly constructed is developing structural cracks suggesting the need for more comprehensive architectural drawings. New fields of inquiry promise severely to stress Science's present frameworks of time, space, form and substance. ESP or Psi phenomena can no longer be denied or ignored in spite of the difficulties of treating them in accordance with scientific validating and falsifying procedures. The ontological dimensions introduced by psychedelic drugs challenge conventional concepts of "reality" and require a new parameterization of our channels of perception (3).

As with all epistemologies, the epistemology of science focuses on what it <u>can</u> do--which is not always the same as what may be important to do. In the present society, good scientists (i.e. successful scientists) are those who work on problems intuited to have a high probability of being solvable. This strategy is certainly appropriate for a young and incompletely tested epistemology. However, in a well established epistemology the displacement of signification-per-importance by signification-per-success imposes biasing restrictions on the directions of inquiry. These restrictions tend to generate a corpus of knowledge that is more likely to map the superficial in the cosmos than the fundamental. The ubiquitous canon, "we should do what we can do", architects distortion and imbalance in epistem, waste and absurdity in praxis.

Science's obsession with "objectivity" seems both futile and pretentious against the backdrop of its opportunistic approach to signification. "Objective knowledge" is the label pasted on the product of the process that begins with human experience, organizes it into a self-consistent structure, then decants the human experiencer. This de-subjectified knowledge after being transmitted and stored by human intellects is applied by human agents to modify the world and its human contents in accord with designs made by human planners. It is not clear why one should seek to remove the sub-system of the experiencer from a world system in order to obtain knowledge of a world system that contains experiencers. It seems rather that the type of knowledge needed for praxis or action must be based on the total system in which the action is to be executed. For example, a science of healing that focuses on the human as object to be healed but ignores the properties of the subjective human as healer will find such phenomena as "faith healing" outside its purview. Such a science must either deny these phenomena or term them "miraculous". There may be nothing miraculous about them at all for a science that studies the world system without excluding the properties brought into it by such higher level sub-systems as humans.

The epistemology of science has had another unsought side effect. It has robbed man of meaning. In the words of Nobel Laureate, Alexis Carrel (4), "Science has made for man a world to which he does not belong". This has been brought about not only through the pursuit of objectivity but through the analytical process of scientific epistemology which is by its nature " a basilisk which kills what it sees and only sees by killing" (5). The atomistic facts that are the excrement of analysis are not the prior-to-analysis holistic system, rich in all of its interior and exterior relationships. We have built a knowledge of the dead pieces devoured and digested by analysis and not a knowledge of the undevoured living world which can never be obtained through this process. Analysis is for the purpose of explanation and explanation is concerned with parts. An explanation is a description of the <u>contents</u> of a system and how it works. Meaning, on the other hand, is a matter of relationships, especially relationship to the <u>context</u>, arrived at through considerations of the whole. It is not surprizing that there is a crisis of meaning in a civilization that is built around an analytic epistemology. It is also not surprizing that our models of the world system are concerned only with the inner workings of the system and rarely, if ever, give thought to the system output. What indeed is the output? What is the function of the world system with its life and intelligence with respect to its total context? Such questions are called"unscientific" and perhaps are properly eschewed by Science since they are intractable in its epistemology. But such questions stand nonetheless as primary driving forces for all human inquiry.

One of the most important sources of the requirement for new epistemologies is the need for the capability to validate and significate all types of human experience. The present epistemology of science has proven its worth for experience that is continuous, ubiquitous and repeatable. It encounters difficulties or an impasse, however, where experience is intermittant, infrequent or where paribus ceteris cannot be invoked. This has resulted in the quality of scientific knowledge being dependent on the subject area of the knowledge. The highest quality knowledge under the epistemology of science centers in those disciplines such as physics, astronomy, etc. where the level of complexity of phenomena is such that repeatability is not obliterated by a profusion of parameters. In general the quality of knowledge decreases as the system complexity increases, reaching a less than satisfactory state in the highly complex behavioral sciences where unique events that are scientifically untractable may carry the greatest significance. For it is not apodictic that the regular and the universal are sufficient to account for the structure and dynamics of the cosmos and its sub-systems. The unique and the exceptional--which for the most part lie beyond the firm grasp of the epistemology of science--may have a significance as great or greater.

The need for epistemologies that will allow us to validate and falsify where samples are small, repeatability not possible, or where unique events overide systems parameters, will not necessarily be met through some single all inclusive epistemology. We should not expect a single epistemology that can equally well subsume sense experience and extra-sensory experience; equally well significate mystical experience and practical planning; equally well validate deterministic systems and normative systems. We should seek to develop critical methods for collecting, testing and signifying appropriate to each type of system experienced, rather than trying to make one shoe fit all feet and judging the quality of the feet by the fit of the shoe.

One of the central concerns of General Systems Theory is with methods and frameworks for the unification of knowledge. There can be no unity of knowledge until there are a) epistemologies suitable for every type of experience and b) a framework --space, time, causal, etc.--of sufficient breadth and depth to permit the formulation of hypotheses and models to account for all the types of experience. A presupposition of Systems Philosophy is that the world is intelligibly ordered as a whole (6). Although the world appears to function as a whole our best representations come out piecemeal. If the world is a whole, there should be some complex multi-level representation possible. The design of such a multi-level construct depends on a methodology for the valid organization of systems into a suprasystem. Whereas the inverse problem of analytical resolution of a system into subsystems is readily treated by such top-down approaches as deduction, and single level systems are amenable through induction or statistical procedures, there is no corresponding technique for vertical bottom-up organization. This lacuna is a task for new epistemologies.

Further epistemological requirements are generated by another concern of General Systems Theory. This is to derive and validate the basic principles and meta-principles that commonly govern physical, bio, socio, eco and artificial systems. This task has a resemblance to the epistemological step taken by the Greeks on a more elemental level when they were able to replace such statements as $3^2 + 4^2 = 5^2$ and $5^2 + 12^2 = 13^2$ with the meta-statement $a^2 + b^2 = c^2$, valid for all right triangles. But before this could be done the validating process of deductive proof had to be perfected and incorporated into their epistemology. The General System theorist of today faces a similar epistemological task in the development of suitable canons for validifying and falsifying meta-statements concerning systems behavior. There are, for example, analogies between linguistic and biological evolution, between the evolution of organisms and of artifacts; there are Zipf's relations (7) between rank and population for cities, or rank and frequency for words in manuscripts and similar rank-frequency relations in many diverse systems; there is the two-third power law relating the sizes of external and internal components of organizations analogous to the surface area and volume of the interior of metric solids (8). What kind of "$a^2 + b^2 = c^2$" meta-statements can be made in these cases and what level of validity for such meta-statements can be established? In other words, is there a General Systems Theory?

Systems may operate in one or more of three dynamic modes: deterministic, telic (or normative), and probabilistic. In the past it has been customary to argue which of these three modes exclusively governs the dynamics of the world system. Today we are finding it more useful to postulate the co-existence of all three and forego the futility of trying to reduce any two to the third. However various sectors of the intellectual community still prefer to assume the exclusiveness of one mode for their own purposes. Macro-physical scientists tend to assume the deterministic mode applies exclusively in their systems;

micro-physical scientists, the probalistic mode; and social scientists, the normative mode. This places the subject area of the bio-scientists at the level where modes interface. If biologists opt for an exclusive mode (as most do) they encounter the lacunae of reductionism or those of vitalism. If they opt against exclusiveness they encounter the epistemological problems of interfaces. In general terms, the modes may be discriminated by some first order attributes: Deterministic systems are closed-ended, causalistic, reversible, predictable and receive their inputs on the operational (energy) level. Normative systems are open-ended, finalistic, irreversible, forecastable and receive their inputs at various control (informational) levels. Probabilistic systems are locally open-ended, generally acausalistic, irreversible, unpredictable and appear to generate their inputs autonomously. (Ensembles of probabilistic systems, on the other hand, are closed-ended, irreversible and forecastable.) Since General Systems Theory is concerned with all species of systems, the nature of these modes and their interfaces (or, it must be allowed, their possible reducibility to one another) constitute a central task for general systems research.

First are the difficulties with the view of time employed by Science. It is no longer expedient to ignore the finalistic--future influencing the present--aspects of normative systems simply because they cannot be subsumed in the historical notion of time developed in accordance with the causality principle operating in deterministic systems. The bio and social sciences have had to build their models around too narrow a notion of time. Whether or not such difficulties as are implicit in the reductionism vis-a-vis vitalism impasse could be resolved by a more comprehensive view of time cannot be claimed. But General Systems Theory should recognize that departures from the "strict constructionalism" in certain frameworks of Science--such as time-- are necessary if we are to develop the new epistemologies needed for processing and synthesizing all human experience.

Second is the matter of values and value systems. Normative systems in being open-ended are directable through choices made among a set of images of the future. Choices in turn are narrowed by decision algorithms which include in their steps the application of values and value systems. Science prides itself on being value free. This (without the pride) is an overt admission of its inability to cope with normative systems. But this inability derives, as we have seen, as much from the limitations of its notion of time as from Science's epistemological value of objectivity. The resulting exclusion of investigations by Science into values and value systems has created a critical shortage in our body of knowledge, with derivative malnutritional maladies in our bodies politic.

Related to normative or telic systems is the subject of telos itself. The properties of telos--purposful or finalistic behavior--have not been adequately investigated. We do not know, for example, the level of complexity at which telos first appears within a system (or whether telos is ever <u>within</u> a system but always must bear a contextual relationship). Nor do we know the relation between telos and consciousness or between telos and life. Telos may be an essential concomitant of life appearing on the systems scala at lower levels than consciousness. Or all three may occur in various orders at various levels of the system scala depending on time and other systems parameters.

The foregoing considerations:

> Our axiologically and epistemologically rooted crises; the traps of objectivity; the denial or de-signification of areas of experience that are not amenable to an epistemology designed for the repeatable and the ubiquitous; signification per self directing successes; the absence of holistic and contextual considerations with the consequent desication of meaning; the exclusion of normative systems together with their concomitants of values, value systems and telos; the need for ways of validating and falsifying the propositions of General Systems Theory; the need for unitary frameworks of space, time, structure, etc. and for techniques of synthesizing that will permit the unification of knowledge.

These, individually and summarily, create the requirement for new epistemologies and frameworks. This requirement broadens the traditional concept of an epistemology. No longer is epistemological concern limited to what knowledge is and the ways of knowing. It must consider the entire "knowledge system", i.e. the collection, filtering, organization, testing, interpretation, evaluation, recording and transmission of experience. It must consider the nature of the growth of the corpus of knowledge and the various feedbacks that the existing corpus inputs to the growth process. It must consider the morphology of inquiring systems. In all of this General Systems Theory not only has basic requirements for new epistemologies and new frameworks, it also has basic contributions to make toward meeting these requirements. The general systems approach appears to provide the best conceptual point of departure for researching the knowledge system. Only a comprehensive open-minded, yet critical, view such as that taken by General Systems Theory will suffice for realizing the epistemological requirements that have been outlined here. The assumptions and aims of General Systems Theory are facilitating to the structuring of suitable epistemologies for many areas of experience and for organizing them into a unitary framework. The close parallel between these epistemological tasks and the aims of General Systems Theory makes it appropriate to introduce the term "Systems Epistemology" for this systems oriented study of the knowledge system. We shall use this term with this meaning in the following sections.

The Characterization Of Epistemologies.

The knowledge system bears the same relation to human society that the genetic code bears to human life. Epistems are genotypes, praxes are phenotypes. Innovation takes place in genotypes, testing in phenotypes. The requirement for a new epistemology is thus no less than a call for a genotypic modification, an altering of the knowledge system's genetic code. Genotypic modifications, whether biological or epistemological, are challenges of the highest order. The analogies between the two systems should prove to be mutually helpful to the bio-geneticist and the systems-philosopher in examining the aims and the consequences of their parallel tasks in "code modification".

We may take a second analogy to further illustrate the systems nature of epistemology. The basic components of an epistemology are a community of experiencers, a set of ways of experiencing and an aggregate of experiences or things experienced. We may think of the sources of the experiences as transmitters, some of which most experienciers or receivers can tune in, while some are available only to a few receivers at irregular intervals. In this metaphor the various senses (physical and other) are the communication channels and the experiences are the messages received. (It should be pointed out that we deal only with the messages and not with the transmitters. The "true nature" of the transmitters, i.e. the nature of "reality" is an ontological not an epistemological question which is not relevant here.) Knowledge is the organization that the community of experiencers places on the representations of selected sub-sets of their experiences. An epistemology consists of both the imposed and adopted rules employed by the community of experiencers for the collection, representation, filtering, organization, evaluation and application of their experiences. The term "community" implies that the experiencers share, at least in part, the ways of experiencing and, at least in part, the same experiences. This further implies that the members of the community each possess a copy of the code book that allows them to communicate with each other the encoded representations of their experiences. The imposed rules are the constraints that limit the experiencers in their ways of experiencing and in bringing to consciousness their experiences, i.e. in our metaphor, the basic frequencies and band passes of the channels and the sensitivities of the receivers. The adopted rules are the conventions agreed upon by the experiencers for the processing of their experiences. Different epistemologies may be parameterized in part by their adopted rules for validation, signification, etc. These rules, in turn, depend on the relative emphasis placed on certain epistemological values such as objectivity, consistency, elegance, etc.

Epistemologies may also be characterized in terms of their "volumes" in three types of space: an experience space, a model (or construct) space, and a cultural space. The dimensions in the experience space correspond to such parameters as the number and properties of the channels through which the experiencer receives his experience, (such as the sense channels); the nature of the signals coming over the channels, such as their intensity, frequency of occurence,, duration and continuity. The properties of the experience space are generally fixed and correspond to the imposed rules governing the epistemology. However through the development of sensory extension instruments such as telescopes, thermocouples and spark chambers and through the development of consciousness extending techniques such as bio-feedback displays, psychedelic drugs and meditative disciplines, the volume in experience space,which is a measure of the experiencable domain of the phenomenological world, may be enlarged.

The model space usually has three dimensions corresponding to the three basic epistemological values of comprehensiveness, precision and simplicity. The volume in a model space measures the epistemological utility of a model, theory or explanation (9). The larger the domain of experience over which the model is valid, the more precisely it maps experience and the simpler or more economical it is, the higher its overall value. However, there are some trade-offs between these three values. Precision frequently must be bought at the expense of simplicity and field of view (comprehensiveness) traded for resolving power (precision).

The third space, a cultural or societal space, has to do with the social acceptability of an epistemology. Its dimensions are the length of time the epistemology has been culturally established, the number of people (weighted by their social importance) who subscribe to it, and its successfulness as measured by its ability to meet certain cultural values such as utility. (Successes are also functions of the volumes in model space.)

From these characterizations we see that in both model space and cultural space there are components of the knowledge system that contain values. The knowledge system is thus in part a normative system involving choices that establish these values, a fact contradicting any pretentions to absoluteness for an epistemology. The shape of the corpus of knowledge results from the imprints of these values, giving us the strategy of "value-perturbation" as a way to detect unsuspected adopted filters that limit our experience. Different epistemologies not only focus on different regions of experience space but tend to adopt different values for their model and cultural spaces. For example, the epistemology of Science and the epistemology that the Greeks called "doxa" and we call common sense are both primarily concerned with the same experience space--that of the physical senses. (Science, however, is more deeply involved with instrumental extensions of sensory experience space.) These two epistemologies differ in their model spaces primarily through Science's much greater emphasis on precision and less concern with simplicity. The two differ in their cultural spaces primarily through Science's emphasis on success and doxa's emphasis on body counts. Only in Science and in certain axiomatic epistems such as mathematics are there highly formalized validating procedures. Doxa validates through "workability", which as time passes drifts toward validation through tradition or the validation through the authority of body counts. The epistemologies used by various "occult" disciplines usually validate directly through the authority of some individual or text. It must be noted, however, that validation by authority is not entirely absent from science.

Authority in Science, however, operates not on the level of fact validation, but on the level of prescription and proscription of methodology. For example, in the so-called Velikovsky Affair (10), Velikovski's facts turned out to be correct but they were opposed because they were obtained by using a methodology unacceptable to Science.

Mystical and religious experiences possess no formal epistemologies or validating procedures. The nature of their experiences tends to be highly personal and oftimes much of it is not communicable. Such experience obviously cannot be passed through the filters of repeatability and ubiquity that are imposed rules of epistemologies that are based on the least common denominator of general communicability, as are both Science and doxa. The basis for validation in these areas of experience, when it is not some authority, is an "inner-recognition". Inner-recognition is a "gut-level" ultimate in the act of knowing-- a sort of resonance with what is true. It underlies the criteria by which we are guided in the construction and testing of our formal epistemologies. It is the court of last and highest appeal, transcending pragmatic criteria which are always associated with an interval of time in their propositions of validity. It is important, however, to discriminate inner-recognition from the "hunches" and "feelings" and other gestalt perceptions that we lump all together in the English language under the term <u>intuition</u>. Inner-recognition and gestalt sense perceptions belong to different levels of intuition. These levels constitute an important sector of study for new epistemologies.

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We have noted in the case of doxa the tendency for success to lead to the establishment of the authority of tradition. This is an evolutionary tendency in all epistemologies, perhaps the basic dynamic of the cultural space. But authority on whatever level, once established, diminishes the frequency of appeal to either pragmatic tests or inner-recognition. These important feedback loops in the knowledge system tend to atrophy under the warm glow of past success. An epistemology is one system that cannot afford to be governed by the popular adage, "If you find something that works, stick to it". Vital and effective epistemologies have no orthodoxies, they must be periodically reviewed and renewed on every level.

Approaches to a Systems Epistemology.

How do we begin to meet the requirements for a unifying meta-epistemology that will enable us to build a knowledge system,containing the essential features of "genetic tapes",and going beyond, provides a suitable "cultural tape". It is not easy to modify epistemological patterns of thought and practice that have become so ingrained as to be invisible to us. The evolution of these patterns has been slow and painstaking, requiring generations for experiential feedback to effect changes. Now we are asking for a new epistemology to be designed in years not generations. Such a meta-revolution feels subversive on everybody's list. Clearly this is not a task for any one group or school of thought. It can only result from the integration of many ideas and approaches. Four essential steps appear to be involved:

1) Development of awareness of the need for a Systems Epistemology.
2) Critiquing existing epistemologies and epistems to find a fundamental parameterization of the knowledge system.

3) Utilizing this parameterization to generate a morphology of alternative sub-systems to function within the knowledge system.

4) Evaluate and select suitable sub-systems. Integrate these into a Systems Epistemology.

The first section of this paper contained some remarks applicable to step one. The second section sketched a few ways of looking at epistemologies relevant to step two. Since steps 3) and 4) depend on the completion of step 2), we can go no further at this time. The remainder of the paper will discuss a few epistemological miscellany useful as "Hilfsmittel" in the various steps.

Matters of attitude are among the prerequisites for a Systems Epistemology. One important attitudinal problem is how to achieve an effective blend of openness and criticalness. Openness is frequently threatening because it might expose work involving a considerable investment of time and effort to inputs that would invalidate it. The response to this threat from openness is oftimes to employ criticism as a wall to shut out innovative inputs rather than as a tool to evaluate them. Proper criticism, however, is based on consciousness of where we are and what we are trying to do and this consciousness does not fear openness, fuzziness or the tension of deferred validations.

A useful approach that effectively combines openness and criticalness has been described in the rubrics of Zwicky's Methodology of Morphological Construction (11), a methodology useful for syntheses. In Zwicky's technique one employs a temporal pattern of alternating expansion and contraction: An expansive phase of unencumbered imagination of possibilities followed by a contractive phase of critical evaluation and decision among these candidate possibilities. The alternating pattern in time is the essential feature. It is defeating if the imaging and the critiquing phases are not kept scrupulously distinct. Without a season of freedom from criticalness the full powers of the human imagination cannot be released for giving birth to innovations; without a season of focus on criticism, free from the disruptions of novae, no model can be built. Without the temporal pattern of alternating openness and criticalness there could not be the temporal pattern of innovation and construction, innovation and correction on which the growth of the corpus of knowledge depends. Otherwise all would remain either permanently fluid and nebulous or permanently rigid and ossified.

The ability to employ such an alternating pattern depends on an attitude that can withstand the tensions of postponed resolution of antithetical concepts, (admittedly a difficult stance for the "now generation"). Resolution and decision are required for praxis not for epistem. Action and implementation demand the convergence of option space; but it is otherwise profitable to keep the stock of possible alternatives as rich as possible for as long as possible. One of the longest unresolved tensions in the history of science had one of the most fruitful resolutions, when finally it came. This was the particle-wave tension and its subsequent resolution through the quantum mechanics. Had not Huygens' wave model possessed such a broad experiential base, it is possible that certain of Newton's followers using their customary Cromwellian clout would have succeeded in resolving the particl-wave question in the 17th century in the usual manner through repression. However the co-survival of the two antithetical viewpoints provided a stimulating and fruitful tension within physics that delayed resolution until it could be made through synthesizing rather than through opting. Alternative models and perspectives are useful even when their claims for adoption are not so nearly equal as in the wave-particle case. Alternatives oftimes provide us with stereo vision.

Postponed resolution of epistemic tensions would have an important effect on the manner of growth of the corpus of knowledge. The present manner of knowledge growth resembles that of crystal growth. Both grow through a process of epitactic accretion to the outer surfaces of the existing bodies. In epistemology explanation of the new is always in reference to the terra cognita of the well established corpus. In fact "to explain" generally means to relate to the familiar. The custom of insisting on this one restrictive type of relation -- linking new discovery to the main corpus -- results in the restriction of growth to epitaxis on a single continent of knowledge. In this process the "islands of knowledge" that cannot immediately be related to the main body have small chance of survival. Only when an island provides some compelling utility or economy can it survive without being explained. For example, Heaviside's operational calculus was too useful to discard even through it could not immediately be validated. The Titius-Bode Law of planetary distances has survived over a century without explanation because it discloses an intriguing simplicity of organization. But the general rule for new experience is "be explained or perish". If the tension of unexplainable islands could be sustained then epistemic growth could proceed through the growth of each island and whenever possible through the relating of islands to one another without the necessity of their being related to the continental corpus, i.e., of being explained. A current example of an island of knowledge is the UFO phenomenon.(12) The non-epitactic approach to UFO's would be to postpone explanation in terms of psychology, extraterrestrials, or whatever, and synthesize the various patterns contained in the observations; then utilize the patterns to provide the specifications for the design of a "flying saucer" going as far as is possible by employing known relations and in this way isolate the lacunae in our knowledge. These lacunae will probably provide the keys for a future explanation. But since UFO's cannot now be explained, the epitactic process chooses either to dismiss or supress the subject instead of encouraging the island to grow. In this case trouble was even taken to establish a hierarchy of committees to validate the suppression.

The basic question regarding islands is not <u>explanation</u>, it is <u>authentication</u>. To authenticate a body of experience usually means to establish the existence of a non-illusory, non-chance, internally consistent set of events. In a systems epistemology that must treat with the roles of both illusion and chance, authentication is better defined more generally in terms of the existence of some critical size for relational patterns whether or not illusion and chance be present. The epitactic approach, in focusing on the features that relate new experience to the main body of knowledge, gives a preferential status for purposes of explanation to those systems that, for whatever historical reason, happen to have been examined first. Since the first systems to be successfully studied scientifically were those lowest on the systems scala -- physical and chemical -- explanation for new experience must be made in terms of these systems. Thus reductionism is an imperative of an epitactic epistemology. If other systems than chemistry and physics had had this primacy of study they would also have had primacy for a role in explanation.

When Apollo 8 brought back the first pictures of the blue globe of Earth floating in space, we received a new paradigm for our epistemologies. Instead of viewing structures as being based and dependent on some main body that is foundational for all components, we now can see that a foundation is but one more synapse in the structure, and like all the other links and synapses, it too floats. Relational links of every sort between synaptic islands are para-explanations. Our epistemic structures will be richer and more comprehensive in so far as we allow the great variety of linkages that may exist between various islands to enter, whether or not these linkages exist between each island ~~the~~ and the primary corpus. This is, in the language of systems commonalities, the basic aim of General Systems Theory.

In summary, the requirement for new epistemologies is primarily to supplement the epistemology of science. The past successes of Science have encouraged us to endow it with the future promise of unlimited success in solving all problems and leading us to the realization of whatever goals we seek. But this is unfair to Science. Those working closely in and with science do not make such claims nor encourage such expectations. In fact, the more closely one works with the epistemology of science the more clearly one sees its limitations -- limitations of the sort pointed out in the first section of the present paper. However, the call for new and supplementary epistemologies is not likely to be heeded in face of the myriad successes of Science. But success does not get corrected and we may expect that the destiny of Science is to experience the "failure of too much success". Before this happens those concerned with preserving whatever positive has been achieved in the cultural tape must begin to make the needed corrections and to broaden the base for the critical acquisition and evaluation of knowledge of whatever nature; new epistemologies, one appropriate for each domain of inquiry, must be structured; and the whole unified under a comprehensive framework that permits experience of every sort to be modeled. This set of new epistemologies, together with that of science, and the coordinating framework for their synthesis is what we seek here under the designation, Systems Epistemology.

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METHODOLOGIES AND EPISTEMOLOGICAL SYSTEMS

During the past two decades we have become aware of a new revolution which is taking place in the realm of human thought. This revolution is not a second stage in the scientific revolution as much as it is an extension of the scientific revolution to larger classes of problems. To understand this let us look briefly at the history of the scientific revolution itself.

The first universal class of problems which man considered in a formal way was the epistemological problem. That is, the problem of knowledge. The Greeks were concerned with not only acquiring and classifying knowledge, but they were concerned with the process of acquiring and classifying knowledge. This is the subject they designated as epistemologic.

The first class of problems accordingly for which a systematic method of problem solving was evolved were those universal problems which came from the natural order: the problems of the motion of the bodies of planets, the problems of the motions of objects rolling down planes. These problems became what was known as natural philosophy and began to receive attention of men in and out of universities beginning in the seventeenth century.

The subject area of natural philosophy gradually broadened including anatomy, other branches of physics, and chemistry, and at the same time the subject matter broadened, systemization was taking place in the techniques and methodologies by which study of the natural order was to be conducted, especially through the work of Bacon, [illegible] and others. This structuring of the techniques by which the subject matter of natural philosophy was to be investigated became what we call today the scientific method. Science and the scientific method were thus spawned and nurtured in natural philosophy. Today we have come to view the scientific method as a general method of approach toward not only problems of natural philosophy, but also in increasingly broader areas such as sociology, psychology, and areas that we now call social sciences.

However, the scientific method as derived in the original areas of natural philosophy, has not proven particularly fruitful in areas of social sciences. In addition, the scientific method is encountering many other limitations. There are large classes of phenomena which for one reason or another, to be discussed later, are not amenable to treatment by the scientific method.

Since World War II a new concept has been taking shape. We have rediscovered problem orientation, and have come to realize that the fundamental task of the human intellect is the solving of problems and that the acquiring and systemizing of knowledge is only one of a subset of important types of problems that the human is faced with. Other problems are how to win a war, how to construct an economy, how to develop a nation, how to bring up our children, and so on. It is not surprising that the scientific method should have limited validity in coping with problems of this sort. During World War II, military exigencies required that a "scientific approach" be applied to the solution of military problems. This was not the application of the scientific method, rather this was originally an attempt to extend the scientific method but finally was the development of an entirely new methodology which should not be confused with the scientific method. This was the methodology which we now call operations research or systems analysis. Thus we began to systemize a technique for solving other types of problems than the purely knowledge problem of natural philosophy. The result was a different kind of methodology, one which in fact had important feedbacks upon scientific epistemology. The result has been that today the classical scientific method has itself become only one of a set of methodologies which are useful with the knowledge problem.

Whereas the goal in natural philosophy has become quite clear, it is to increase our knowledge and the central problem is how to discover new factual knowledge and relationships in the area of scientific knowledge. The goal in other problems is quite often how to optimize some parameter, such as how to most efficiently win a war, how to maximize profits, or in general, how to reach some stated goal in the most efficient manner. Recently in a very broad context the subject of how best to acquire new knowledge in connection with the United States space program in the most effective way, recognizing limited resources, has given rise to an interface between two or more of the basic methodologies. The scientific method and an operational research approach have to be joined in order to structure this overall optimization problem.

The best way to study methodologies is first of all to study problems: What a problem is, what its constituents are, what classes of problems exist and finally what techniques exist for their solution. This will be the subject matter of the first section. For example, I.B.M. has decomposed the problems which commonly occur in the operation and management of a large business in to about ten classes. These problems include the inventory problem, the allocation problem, cuing, routeing, and sequencing problems, the replacement problem, the competition problem, and the search problem. Some of these, as optimization problems, have been completely solved and computer programs are now available as off the shelf items for their solution, which can be adapted to any business. For example, impact is I.B.M.s software solution for the inventory problem. PERT, the familiar PERT Charts, are the solutions to the sequencing problem, etc..

We are well advised of the importance of the computer revolution, but independent of the hardware aspects of the computer revolution there is what we might call the software revolution, and the software revolution has sprung primarily from the computer revolution but has introduced a great many new concepts into the area of methodology which in the long run promise to be more far reaching than the computer revolution itself. We have come to recognize that one of the most important strenghts in any corporation, any nation or in any individual, and the strength underlying most others, is a problem solving competence. Problem solving competence means the ability to identify, to formulate and to solve problems of all types. It also includes a methodology of determination of what problems are most significant to be attacked in an area of limited methodological resources. Problems solving capability is the invisible measure of national and corporate strength and survival potential, and it more than any static measure, such as GNP, production levels or weapon systems, and more than any weapon, military or political posture is a measure of our strength today and in the future.

The awareness of a problem orientation in methodologies will reflect itself in a revolution in our institutions. The knowledge problem was the first for which the systematic methodology was evolved and the only recognized universal problems in the seventeenth, eighteenth and nineteenth centuries were those of natural philosophy. Hence this revolution took place largely in the universities and science and scientific research were admitted to the universities and came into prominence in the nineteenth century. However today we see not only the recognition of other universal problems than the knowledge problem, but the new methodologies and the extension of systematic methods to the solution to large classes of problems entering into the university, but also we see the creation of new types of institution for these new methodologies.

In fact the primary institution which has spawned the new methodologies has been the industrial research laboratory and the independent non-profit research organization. These types of institutions, far more than the university, have pioneered in the development of the new methodologies. Such organizations as the Bell Telephone Laboratories, The Rand Corporation and the General Electric Laboratories, are all recognized as having made great contributions in systems analysis, operations research, game theory, and other new methodologies. Although there is a feedback to the university from these new institutions, and even a feedback to scientific epistemology, the frontier of the new methodologies is where the problems are and these problems are found mostly in the complex arrangements required to manufacture, design and distribute products of large monies, such as aerospace companies.

The new methodologies are creating a revolution within the corporations and universities, for example the age of expertise in specialties is being replaced by expertise in problem solving methodologies. Specialists and consultants, that is, the traditional scientist, are still very much needed in the inventory processes required in problem solving. But the central theme must be carried by those still in problem solving methodology. For this reason many corporations feel they must have their own "think tanks", which are primarily centers with high problem solving competence. It should be pointed out that these groups should be neither phenomena oriented nor problem oriented, but rather problem solving oriented.

Each corporation through its think tank must have specialists and access specialists. It must have methodologists. These methodologists may be experts in special types of problems, and as such are usually currently known as executives. These are men who make practical applications of methodologies, management problems and detect and formulate problems. In the new order executives become primarily problem solvers and routine administration is relegated to the computer. And finally there must be researchers in methodologies: those who develop new methodologies and spend their time in studying how to solve problems in general. Thus we shall see the executive of tomorrow more and more concerned with structuring and modeling his business in a computer simulation and having the answer that the computer gives automatically acted upon. In other words, the important decisions will be those of the inputs to the computer rather than whether or not to act yea or nay on the output of the computer. Thus the computer will not replace the executive, but it will displace the executive so that he must perform an entirely new type of operation in the business to the operation that he performs today.

There is an important example of this already in existence where national policy has in many cases been the acceptance of a model of a political situation which has been formulated by members of a think tank. The political executives in the government have the decision whether to accept or to reject a particular model, but the real definition of choice is made by those who formulate the model. Thus those who are really shaping U. S. policy are those who work in "think tanks" such as the Rand Corporation, and who synthesize models of the world political situation. The important decisions are those governing the assumptions which go into these models. We thus find that the know how and wisdom of those who formulate the models plays a far greater role in shaping of national policy and even a role of power and influence in the country exceeding that of those who sit in high office and merely respond to what is placed on their desks. The development of this situation has tremendous implications and dangers for the traditional functioning of this country as a democracy. If one of the most important features of our form of government is the visibility of those who rule us, we must arrange that those who formulate the models be recognized as an important constituent of our government be chosen on the basis of outstanding competence and on the basis of broad and diverse backgrounds, and that these men furthermore be responsible to the people in some way.

D R A F T -- Wilson, 7-15-69, Diana Jackson

NOTES FOR PROLOGUE Edelen Book

I. THE DICHODOMY BETWEEN THE BINARY AND THE ~~POOR~~ POLAR

The classical mode of human thought is to reduce all dichodomies to the special case of a binary dichodomy. By a binary dichodomy we mean a dichodomy of absolutes in which all is divided into two mutually exclusive non-overlapping exhaustive classes A and not A, plus and minus, and so on. The examples of binary dichodomies include electric charge and usually we think of truth as binary. A proposition is true or it is false. We think of existence as binary. An entity exists or it does not exist. We think of discreetness as binary, something is discreet or it is continuous -- it cannot be both. In contrast to binary dichodomies, we've also defined what we call polar dichodomies. In a polar dichodomy there exists a continuous range between the two extremes. For example, instead of having the absolutes, true and false, we have the true and false appear as poles and that propositions occupy a continuous range between true and false. Or a continuous range between the purely discreet and the purely continuous, at the other. We may also imagine that existence itself may be ~~poor~~ polar rather than binary and that existence is a matter of occupancy somewhere along a continuous range between existence and non-existence.

Although the classical mode of thought and the basis of Aristotelian logic is to organize our patterns of thinking into a binary system, human experience indicates that it is better to approach the world in a ~~poorer~~ polar system. Scientific thought has long recognized the partial nature of our knowledge and has recognized that ~~the~~ approximation underlies all our constructs. It follows that the absolutes, true and false, are incompatible with the epistemology of creatures such as man that possess limitations of sense, limitations of computing capability, limitations in space and time, and limitations in knowing. Since we can only know in part, we cannot term our knowledge true or false -- we can only judge the patterns we percieve by whether they are useful to us or whether they appear beautiful to us -- although these may be measured along scales that permit ordering. To say that one construct is more useful or another construct is more elegant, but is wrong to name a construct true or false. (?) Hence it will be useful to reexamine all of the quantities that we have considered as absolutes in a binary sense and see whether or not they may be better considered in the ~~poorer~~ polar mode. Existence and non-existence as ~~poors~~ polars attributable to successive thresholds of our sense awareness. Truth and falsehood as ~~poors~~ polars attributable to our degree of usefulness or the degree to which precepts and concepts seem to map the world. Or discreetness continuous itself as ~~poors~~ polars and that nothing is either continuous or discreet but may be a mixture. We have already considered signal and noise in the ~~poor~~ polar mode where we accept certain objects as being a mixture of the structured and the unstructured or random.

We shall therefore proceed not with the dichodomy of truth and falsehood but by inspecting concepts that are useful to us in providing economies of thought or representation, efficiences of operation, or furnishing us with some aesthetic satisfactions as does the elegance of certain mathematical proofs. We thus will replace tests of validity and verification with tests of usefulness and satisfaction. If we were to examine tests of validity and verification, we would find that ultimately the subjective component enters in; the subjective component that demands either usefulness or aesthetic satisfaction. We shall not go through the detour of self-delusion about truth and falsehood but go directly to what is involved -- the ultimately subjective concepts involving usefulness and aesthetics.

The concepts of true or false is inappropriate for creatures who must procede by successive approximations because of the limitations with which they behold the universe. Thus in binary choice of A versus B we can only say hypothesis A is more elegant than B, or A fits better than B, or A is more useful than B, or A is simpler than B, not that A is true or B is false. Unless the basis of our knowledge is by some other process, than the processes of the scientific method of induction and deduction of the experience of sense, we are not really permitted to use the dichodomy of the binary form, true or false.

In recognition that truth and falsity are ~~poor~~ polar rather than binary we reach the point in human experience when we must face that we are really dealing with the signal noise phenomena. Up to now our knowledge rests on those phenomena in which we have succeeded in filtering out a clear signal from the noise.

The next age will be an age of discernment in which signal and noise are mixed in various ratios. No longer can we expect to view the world in any pristin purity of signal but we must seek patterns of usefulness in which the signal may be imbedded in larger measures of noise than we have hithertofore found acceptable.

If we were to ask "Does a certain discreet distribution function, will map or represent, the set of observed diameters of galaxies,"we are not asking a question, "is it true or false?" All that we are asking is whether this distribution provides a useful map of the observed world, or establishes aesthetic satisfying map. Thus the observer is very much in the picture through his subjective decisions of what is more useful or more aesthetically satisfactory to him. Thus science becomes the subject of the ordering of the useful and the aesthetic, and we usually feel the most useful is that which makes the most reliable predictions.

II. SIGNAL AND NOISE

Rather than saying that signal is the portion of a message or an observation that contains information whereas noise contains none. It is better to say that signal is the component of an observation or message that is useful. Thus we may think of noise in one of two ways: 1. it is that portion of the message or of an observation that is beyond our ability to structure or organize in order to extract information, or 2. it is of secondary or minor interest to us. If we were to classify signal and noise, not by only the ratio of signal to noise, nor by the various types of noise, such as Gaussian noise, white noise, etc., but by the gap between the complexities of their structures we would find that if the gap between the component we chose as signal and the component we reject as noise is large the choice is easy and the definition of signal and noise, and signal to noise ratio is readily arrived. However, if the gap is small it is not easy to decide what is signal, what is noise, or what the proper measure of signal to noise ratio is. We must remember that the ratio signal to noise depends on a priori definition of the components that are signal and are noise.

If ~~seeing~~ signal is useful and noise is ugly, we have married our two criteria of usefulness and aesthetics. We cannot demand as limited creatures that signal and noise be unmixed. We oft times assume ~~the~~ epistomologically that signal may be equated to that which fits the world and noise to that which does not. But this is an improper formulation;

signal must be equated to that which fits our interests and noise to that which does not.

Our problem thus becomes when is it useful to extract a signal and not classify it as noise or reject it because of the high level of noise. We thus need new criteria for deciding when a signal is worth extracting. The picking of a signal out of noise is equivalent to the imposing of a structure upon a large unordered aggregate. Noise is that which is beyond our ability or limits to impose structure. In general, it is only the simpliest things that we are able to structure and hence, represent to us, signal. What we call useful or what we call beautiful, thus, is what matches our limitations to comprehend. The random is nothing more than that which we cannot find a pattern in. When we say there is a high signal to noise ratio, we are saying that there is a possibility to pick out a pattern easily.

In the nineteenth century the term random was associated with the term complex. That which was random or noisy was that which was too complex to be readily structured. Thus statistical tests, such as the Chi Square Test, were not so much measures of the possibility that a given event was created by chance but rather a measure of its complexity. The example of predicting where the ball on a roulette wheel falls is a case in hand, not that it is a matter of chance but that it is a matter too complex to be predictive although we know the laws by which the various components of the wheel and ball function. It follows that we should not judge patterns such as the pattern of discreetization on the basis of Chi Square Tests but rather whether the pattern connects to other patterns, whether it makes predictions, how it is contained in larger patterns, and on the ratio of the number of degrees of freedom to the amount of data that is fit. The interpretations of probability and stochastic extend very broadly the views of Jeffries to those of Neyman, that is the absolutests, those who are uncertain. Edwards, in Nature, (see the notebook on stochastics) has pointed out that it is amazing how much the world has taken to statistics and probability, how broadly it has applied it without considering the weakness of its philosophical foundations and the arbitrariness of its interpretations.

Of basic importance in the evaluation of any hypothesis is the parameters of comprehensiveness and precision. A hypothesis or construct may map a certain area of the observed world with a very high level of precision. It may map a small or a large area of the phenomenal logic world. Both the size of the area mapped and the precision with which it is mapped are factors in the usefulness of hypotheses. Certain standards of both comprehensiveness and precision must be met and these are functions of the age, that is of time.

Goddell's theorum speaks to the inability simultaneously to be both comprehensive, that is complete, and precise, that is perfect. For example, we may build a file we may either have a complete file in which the filing system is not perfect in that it contains a miscellaneous pox, or we may have a perfect file but we must throw away some of the items because our basis for the file cannot be complete. We must choose whether we sacrifice precision to obtain completeness, or completeness to obtain precision. Just as with files, every hypothesis and construct must be subjected to this test -- whether we wish to rank first comprehensiveness or precision in statistical representations we frequently "smooth data". We arrive at a family of statistical distributions such as the Gaussian or Poisson distribution. These are completeness distributions in that they allows us to contain all of the events or phenomena but they are far from being precise or perfect. In order to get completeness by using the methods usual in statistics we are throwing away a very great deal of information. We are using low precision, low resolving power, but we do get comprehensiveness. The fact that science chooses the statistical approach as exemplified by Gaussian distributions, indicates that we prefer comprehensiveness to precision.

Another case in which the decision between comprehensiveness and precision must be made is in the dividing the data in half before we make our model and then use the model based on half the data to effect prediction. The statistician prefers to use all of the dat a and to achieve a model of high precision, however, he looses the test of comprehensiveness through this procedure. Thus in choosing between comprehensiveness and precision we have in this case the test of predictiveness which measures comprehensiveness. While The statistician is willing to sacrifice comprehensiveness in order to achieve precision. the scientist would sacrifice precision to achieve comprehensiveness.

But the use of Gaussian is a sacrifice of information in order to obtain comprehensiveness. So we see that from time to time precision is sacrificed for comprehensiveness and at other times comprehensiveness is sacrificed for precision.

III Polar Epistemology

Epistemology is a systematic attempt to organize sense and thought experience. We organize our sense experience by looking at patterns and regularities in our sense. experience Some maintain that the regularities and patterns that we make are imposed by us rather than being intrinsic. This is a question which may itself have a polar resolution, a question to which we will return later. But for the moment, the basic question is not whether ~~for~~ the patterns are discovered or imposed but whether they are useful or satisfying to us. Whether they are in the eye of the beholder or in the object beheld, is a question we cannot fully decide.

In order for a pattern to be useful it must provide an economy, be classificatory, afford prediction, or establish order or be efficient. In order for a patter to be esthetically satisfactory, it should be elegant, ~~it should be~~ , it should connect to other patterns, it should be simple, it should be the most significant and the most sensitive pattern that we are able to formulate.

~~that~~ The Greeks were concerned primarily with three things. The good, the true and the beautiful. The Greeks held that that which was both good and true ~~could~~ be called beautiful. Perhaps it is better to say that which is useful is good and that which is beautiful that is, esthetically satisfactory, combine to make that which we call true.

We wish to differentiate between three classes of parameters. We shall call these observables, descriptors, and indicators and primitives. Observables are those parameters that are most readily identified by our senses or our instruments. On the level of sense interaction with phenomena, they are ~~de~~ the salient parameters. Descriptors are variables that are useful in showing connections and relationships between various objects and phenomena. Or they are useful in illustrating the properties of entities or phenomena. Descriptors may be observables, but in general, they are derivable from observables. Indicators are parameters that are close to being basic, or provide the key to ~~post~~ the most elegant direct or simple formulation, of a construct. They may be called the most sensitive descriptors and if there were to be an absolute, they are the closest to the parameterization that a being with all knowledge ~~able to~~ would use to formulate the model. The absolute or ultimate indicators are unknowable however, we seek them through successive approximations. With a judgement at any given time being in terms of their usefulness and elegance that they give to us, or the judgement may be according to some tacit or overt agreement upon certain processes by which hypotheses are arrived at.

The regularities may be as said before imposed or they may be intrinsic. It may best be that we think of epistomology as starting with imposed regaularities and patterns, and following a path toward ~~more~~ what we would call the intrinsic parameters in patterns. The pathway from observables to discriptors to indicators is the pathway from the imposed to the intrinsic. But since we are dealing only with representations, and since there exist ~~s~~ many levels in representations, perhaps rather than speaking of the three classes of parameters, observables descriptors and indicators, we should speak of three levels of parameters, referring to the levels on which they operate. These may be levels significance, levels of comprehensiveness, or levels of subjectivity .

Another approach, intrinsic versus the imposed, is through the difference of mode. We may differentiate two modes. We may call one the normative or goal oriented and the other the search, or fact mode. Normative is top down; search is bottom up. Normative is system. Search is scientific method. Normative seeks to control; search seeks to understand. Normative would design the future; search would predict the future. There exists one set ~~of processes,~~ epistemological processes ~~that is~~, acceptable for normative development and another set of epistemological processes for search development.

Difference between structure and classification is that structure is intrinsic; it is discovered; it is received whereas classification is imposed, or invented(!) . Structure uses indicators. Classification uses descriptors. Structure is derived from ~~to~~ serendipity and search. Classification ~~for~~ from normative process. Structure leads us to resonance and harmony. Classification is a manifestation of curve fitting, force and control.

Man operates in both ~~in both~~ the search and the normative modes. Science is peculiar in that it is an attempt of "willed reception." The receptive or search mode is to receive and one must bypass the will. The will mode involves persistence, endurance and force, and seeks to alter. Reception is feminine, will is masculine, receptive is classically that mode of the East will that of the west, ~~And saying that~~ Science is a blend of willed or controlled reception. In this it automatically filters ~~as to~~ what may be received. A prerequisite for reception is security, whereas agressiveness is nothing but the search for security. The creative process involves both the receptive mode and the normative mode. To will, to organize a situation, and this of course means to organize the observer.

V) The receptive mode is to allow the images of imagination to parade before the observer and to interact with them actively, and to select from that which is imagined. Education and television both are forms of imposed reception.

End of Tape III

Part IV Epistomological Process and Test

Whereas in ~~test~~ Past times decisions about what was epistomologically acceptable depended upon the ~~backs~~ facts for the results. In our day the epistomologically acceptable depends upon process. A set of prescribed processes has been agreed upon rather than a set of prescribed facts as in the middle ages. Those results and that knowledge which derives from the prescribed set of processes is acceptable while knowledge derived from processes that are not prescribed is not acceptable. At this time, it may be proper to introduce a new level namely to have a consensus on ~~matter~~ meta processes. That is to agree upon yardsticks by which we can decide which epistomological processes are to be accepted or rejected. In going from facts to processes a very major step forward was taken in broadening the base for human knowledge. It is proper to assume that a great step forward would be taken by breaking the mold of the rigor of processes and going to metaprocesses which would allow us far more freedom in establishing those techniques and processes by which we derive our knowledge.

Prediction of ~~concern with~~ the unknown has been a basic test for the validity of any hypothesis. In the view of the dycotomy between the willed or normative and the search for receptive ~~of te~~ epistimologies, that which stands opposite prediction is pragmatism as a test for validity. Pragmatism contains ~~inquisitely~~ intrinsically a time constant, that is, all pragmatism is defined with respect to a certain feedback time. To say that something works or is useful has ~~inquisite~~ implicit in it, "over a certain range of time." Usually pragmatism is quite provincial in time. The feedback time chosen is so short that it necessarily devalues the importance of change in its considerations. Thus pragmatism becomes reductionist limited to a fixed context or fixed ground rules and does not explore evolving context, whereas prediction basically seeks to explore the evolution of the context.

But perhaps more useful than any epistomological test that we have mentioned and perhaps of the nature of a matatest is what we might call the ratio of output to input in any epistomological construct. This could be something like the number of phenomena explained to the number of assumptions made. So this is a test based on economy and elegance. It involves knowing a measure of the degrees of freedom in a construct. We have in simple cases, problem of fitting ~~10~~ m values with ~~10~~ n free parameters. It is well known the different outcomes possible with having n equations and n unknowns.

We may take for example Kepler's Third Law

It had a certain amount of elegance in that only two parameters were involved: the semi-major axis of the orbits and the period in which the planet revolve. The total sample was small, however the ~~first~~ Kepler's 3D Law proved predictive. Its original acceptance was perhaps because of its simplicity, the fact it fit two parameters but it was also accepted because of precision although it was modified later with the introduction of a mass parameter. But above all perhaps because of its comprehensiveness. However at the time of ~~Capler~~ Kepler his law was new and it could not be said to be tested against how it fit in to the known body of knowledge because the known body of knowledge was largely prejudice (such as prejudice that only circles were perfect and the world was made perfect). When we come to the ~~tidiest bold~~ Titius-Bode law we have ~~here~~ predictiveness, comprehensiveness, simplicity, but it involves only one parameter and it does not tie in to the known body of theory. Which of these later two reasons have militated against ~~Bold's~~ Bode's law as taking an important place is difficult to say.

~~With those task~~ We Ask, why are certain hypothesis accepted or rejected. If we were to give in order of increasing importance tests for hypothesis we may list them as follows:

1. Do they tie in with the existing body of knowledge; i.e. are they consistent and analogous.
2. Are they predictive
3. Are they comprehensive
4. What is the level of precision
5. Are they elegant or simple.

It is well to note here that there exist certain differences in hypothesis involving continuous formulations and those involving discrete ~~relations~~ formulations. In the first place ~~fifths~~ fits in the continuous distribution involves two or more parameters. There are many values to be fitted and consequently many ranges that can be ~~trusted~~ tested. On the other hand the discrete ~~or~~ are limited to a few values to be tested and in general the data is more restricted. But most important discretness ~~use~~ is possible in a one parametered distribution. In other words the discrete distribution may stand on the basis of one parameter ~~can not~~ and be not independent of ~~upon~~ any correlation.

SECTION V ~~Paratechmatic Influence~~ Paradigmatic Inference

It is to be assumed after a certain critical mass of knowledge has been acquired that the overriding test for the validity of new hypothesis becomes how the new hypothesis ~~sips~~ fits into the context of existing theory. This test overrides elegance, comprehensiveness, precision or even degree of fit to the observed world.

In practice the complexity of nature forces us to use constructs that are only partial that is we create substructures of certain domains of the observed world. We are reductionist, we emphasize contents, we tend to ignore the connections of our substructure construct to other constructs. But in structuring subsets and in favoring reductionism we imply that there exist other parameters embedded in context which make the situation more complex and more difficult to structure. Thus we seek perfection in a subset rather than completion and our present ~~tes~~ epistimologies become largely reductionist.

~~Paratechmatic influence~~ Paradigmatic Inference is ~~influence~~ inference based upon statistical tests or any of the tests given ~~either to~~ hitherto, but depends rather upon whether the construct can be fitted into an overall context. Paradigmatic inf~~luence~~erence accordingly evaluates the vertical rather than the horizontal relations.

For Cosmic - Atomic Relations

SOME ~~PROPERTIES COMMON TO~~ PARALLELISMS IN COSMIC STRUCTURES

When, after the lapse of several decades, an observational result continues to defy incorporation into our constructs of the physical world, we tend to minimize its significance and perhaps come completely to ignore it. But it is important from time to time to reexamine some of the old puzzles. Whether or not new concepts and recent discoveries may give further insights into them, ~~but at~~ at least reexaminations serve to remind us that there are unsettled accounts on the books which sooner or later must be reckoned with.

Titius Bode Law

One of these unsettled accounts, a matter which has been around for several decades, ~~is the matter of~~ consists of the coincidences in value between ~~certain~~ the dimensionless ~~constants~~ numbers which ~~occur in~~ can be constructed from the basic constants of microphysics and ~~other~~ those constructed from the basic constants which occur in cosmic physics. Specifically, the ratio of the electric force to the gravitational force is a dimensionless quantity, $\gamma = e^2/GMm = 10^{39.356}$, where e is the charge on the electron; G, the Newtonian gravitational constant; M, the mass of the proton; and m, the mass of the electron. Dirac has ~~and Jordan have~~ pointed out that if, c if the velocity of light; H_0, the present value of the Hubble parameter, the quotient c/H_0 being a quantity with dimensionality length, sometimes called the basic cosmic length or "radius of the universe" ; then the ratio of c/H_0 to the radius of the electron, $\frac{e^2}{mc^2}$ is a dimensionless number also with the value 10^{39}.

When a sufficient number of these unsettled accounts have accumulated the status-quo comes into question.

Further, the ratio of the "mass of the universe" $= \frac{\rho_o c^3}{H_0^3}$ where ρ_o is the mean density of matter in the universe, to the mass of the hydrogen atom is a number which has the order of magnitude of $10^{2(39)}$, which has been called the number of baryons in the universe. The repeated occurrence of a dimensionless quantity the size of 10*39 from measurements of atomic physics (e, m, M), mesophysics (G, c), and cosmic physics (ρo, Ho) has been interpreted to infer some fundamental relation between cosmic structure and atomic structure.

There are reasons, other than these coincidences, such as those suggested by Mach, for suspecting that cosmic structure and atomic structure are more intimately related than the presently known laws of physics suggest. However, aside from the initial work of Dirac and Jordan (mostly in the decade 1937 - 1947) in attempting to construct cosmological models from the implications of these numerical coincidences, little has been done. ~~(There is, of course, the fundamental theory of Eddington, which I do not pretend to understand, which attempts a complete epistemological reassessment, but is not, in our usage of the term, cosmology.)~~ But, the time may have arrived when more can be said about relationships between atomic and cosmic structures and a further examination of this question may now be in order.

In Table I, are given recent measures of the sizes (radii) and masses of the basic cosmic aggregates: stars, galaxies, clusters of galaxies, and second order clusters of galaxies. The entries under the columns R, M, and M/R are the logarithms to the base 10 of the cgs values of the radii, the masses, and their ratios for all of the aggregates. The column N gives the logarithm to the base 10 of the numbers of atoms in a star, stars in a galaxy, galaxies in a cluster, and clusters in a second order cluster. The final column gives the dimensionless ratios in units defined by the hydrogen atom. Most of the measurements upon which this table is based may be found in the literature. Some of the cluster and second order cluster values derive from recent work of my own.

For stars, aside from the sun, the best values for radii and masses come from well observed eclipsing binaries. V444 Cygnus A has the highest M/R value for any well observed star. The second row gives the mean values for 40 eclipsing variables. The third row gives the more accurate ~~well known~~ values of the sun.

For galaxies, M87 (the giant EO in the Virgo Cluster) has the highest M/R ratio for any galaxy for which these values have been measured. M31, and the Milky Way have been extensively studied and possess reasonably good values. The remaining row gives the mean value of M/R for seven galaxies for which this quantity was obtained from rotation measurements.

For the clusters, the value of M/R was determined from the virial theorem. The Average M/R for 7 Clusters, for which no parallax is known, are given, and average values for 4 Clusters, for which distances are known and separated, R's and M's can be determined, are also given.

The mass data for the second order clusters is synthetic, being derived from the product of a mean cluster value of mass and the mean number of clusters in a second order cluster. The sizes are from the estimates of Abell from the Palomar Sky Survey, and of deVancovleurs for the local super-cluster.

The thing to bear in mind is that the entries in the table are for the <u>largest</u> objects with measured parameters, not for average. The values are thus of the nature of upper bounds.

There are two interesting things to note in this table, which, to my knowledge, have not heretofore been recognized. The first is that the upper bound on M/R is the same for each aggregate, namely, 10^{23} in cgs units, or if made dimensionless, expressed in units of M/R for the hydrogen atom, we again arrive at the ubiquitous 10^{39}.

Current cosmological theories, whether evolutionary or steady state, are based principally on models constructed from the Einstein geometric-dynamic field equations under the strongly simplifying assumption that the observed aggregated distribution of matter may be adequately approximated by a homogeneous perfect fluid. This assumption is frequently attacked, but it has the very practical advantage that it renders the field equations more or less tractable.

no ¶ In view of the results given in Table I, it would seem that an assumption more reasonable than homogeneity is the assumption of bounded potential. ~~I propose to investigate the implications of this assumption in the near future~~.
¶ The inequality, $\frac{M}{R} \lesssim \Omega o$, where Ωo appears to be some sort of universal constant, has several immediate interpretations and analogues.

no ¶ In a system of units in which the unit of length λ_1 is the radius of the first Bohr orbit, the unit of mass μ_1 is the mass of the hydrogen atom, and the unit of time τ_1 is the time taken for ~~a photon~~ an electron in the first Bohr orbit to cover the elemental distance, we have $c = E$, and $G\,\Omega_0 = 10^{-39.356}$

The next age will be an age of discernment in which signal and noise are mixed in various ratios. No longer can we expect to view the world in any pristin purity of signal but we must seek patterns of usefulness in which the signal may be imbedded in larger measures of noise than we have hithertofore found acceptable.

If we were to ask "Does a certain discreet distribution function, will map or represent, the set of observed diameters of galaxies,"we are not asking a question, "is it true or false?" All that we are asking is whether this distribution provides a useful map of the observed world, or establishes aesthetic satisfying map. Thus the observer is very much in the picture through his subjective decisions of what is more useful or more aesthetically satisfactory to him. Thus science becomes the subject of the ordering of the useful and the aesthetic, and we usually feel the most useful is that which makes the most reliable predictions.

Tape 3 Notes for Prologue

III Polar Epistemology

Epistemology is a systematic attempt to organize sense and thought experience. We organize our sense experience by looking at patterns and regularities in our sense experience. Some maintain that the regularities and patterns that we make are imposed by us rather than being intrinsic. This is a question which may itself have a polar resolution, a question to which we will return later. But for the moment, the basic question is not whether ~~for~~ the patterns are discovered or imposed but whether they are useful or satisfying to us. Whether they are in the eye of the beholder or in the object beheld, is a question we cannot fully decide.

In order for a pattern to be useful it must provide an economy, be classificatory, afford prediction, or establish order or be efficient. In order for a pattern to be esthetically satisfactory, it should be elegant, ~~it should be~~ , it should connect to other patterns, it should be simple, it should be the most significant and the most sensitive pattern that we are able to formulate.

~~that~~ The Greeks were concerned primarily with three things. The good, the true and the beautiful. The Greeks held that that which was both good and true ~~could~~ be called beautiful. Perhaps it is better to say that which is useful is good and that which is beautiful that is, esthetically satisfactory, combine to make that which we call true.

Leave up to D. Guiliano

levels of descriptors

primary descriptors. those that are linear

We wish to differentiate between three classes of parameters. We shall call these observables descriptors, and indicators and primitives. Observables are those parameters that are most readily identified by our senses or our instruments. On the level of sense interaction with phenomena, they are the salient parameters. Descriptors are variables that are useful in showing connections and relationships between various objects and phenomena. Or they are useful in illustrating the properties of entities or phenomena. Descriptors may be observables, but in general, they are derivable from observables. Indicators are parameters that are close to being basic. Or provide the key to the most ~~post~~ elegant direct or simple formulation of a construct. They may be called the most sensitive descriptors and if there were to be an absolute, they are the closest to parameterization that a being with all knowledge would ~~able to~~ use to formulate the model. The absolute or ultimate indicators are unknowable, however, we seek them through successive approximations. With a judgement at any given time being in terms of their usefulness and elegance that they give to us, or the judgement may be according to some tacit or overt agreement upon certain processes by which hypotheses are arrived at.

The regularities may be as said before ~~in~~ imposed or they may be intrinsic. It may best be that we think of epistomology as starting with imposed regaularities and patterns, and following a path toward ~~more~~ what we would call the intrinsic parameters in patterns. The pathway from observables to discriptors to indicators is the pathway from the imposed to the intrinsic. But since we are dealing only with representations, and since there exist~~s~~ many levels in representations, perhaps rather than speaking of the three classes of parameters, observables descriptors and indicators, we should speak of three levels of parameters, referring to the levels on which they operate. These may be levels significance, levels of comprehensiveness, or levels of subjectivity.

Another approach, intrinsic versus the imposed, is through the difference of mode. We may differentiate two modes. We may call one the normative or goal oriented and the other the search, or fact mode. Normative is top down; search is bottom up. Normative is system. Search is scientific method. Normative seeks to control; search seeks to understand. Normative would design the future; search would predict the future. There exists one set ~~of processes~~, epistemological processes ~~that is~~, acceptable for normative development and another set of epistemological processes for search development.

Difference between structure and classification is that structure is intrinsic; it is discovered; it is received whereas classification is imposed, invented. Structure uses indicators. Classification uses descriptors. Structure is derived from ~~to~~ serendipity and search. Classification from normative processes. Structure leads us to resonance and harmony. Classification is a manifestation of curve fitting, force and control.

Man operates in both ~~in both~~ the search and the normative modes. Science is peculiar in that it is an attempt of "willed reception." The receptive or search mode is to receive and one must bypass the will. The will mode involves persistence, endurance and force, and seeks to alter. Reception is feminine will, is masculine, receptive is classically that mode of the East will is that of the west. ~~And saying that~~ Science is a blend of willed or controlled reception In this it automatically filters ~~as to~~ what may be received. A prerequisite for reception is security, whereas agressiveness is nothing but the search for security. The creative process involves both the receptive mode and the normative mode. 1) To will, to organize a situation, and this of course means to organize the observer. 2) The receptive mode is to allow the images of imagination to parade before the observer and to interact with them actively, and to select that which is imagined. Education and television both are forms of a imposed reception.

Part IV Epistomological Process and Test

Whereas in past times decisions about what was epistomologically acceptable depended upon the facts ~~backs~~ for the results. In our day the epistomologically acceptable depends upon process. A set of prescribed processes has been agreed upon rather than a set of prescribed facts as in the middle ages. Those results and that knowledge which derives from the prescribed set of processes is acceptable while knowledge derived from processes that are not prescribed is not acceptable. At this time, it may be proper to introduce a new level namely to have a consensus on meta ~~matter~~ processes. That is to agree upon yardsticks by which we can decide which epistomological processes are to be accepted or rejected. In going from facts to processes a very major step forward was taken in broadening the base for human knowledge. It is proper to assume that a great step forward would be taken by breaking the mold of the rigor of processes and going to metaprocesses which would allow us far more freedom in establishing those techniques and processes by which we derive our knowledge.

Prediction of ~~concern with~~ the unknown has been a basic test for the validity of any hypothesis. In the view of the dycotomy between the willed or normative and the search for receptive of epis~~tes~~timologies that which stands opposite prediction is pragmatism as a test for validity. Pragmatism contains ~~inquisitely~~ intrinsically a time constant, that is, all pragmatism is defined with respect to a certain feedback time, to say that something works or is useful has ~~inquisite~~ implicit in it, "over a certain range of time." Usually pragmatism is quite provincial in time. The feedback time chosen is so short that it necessarily devalues the importance of change in its consideration. Thus pragmatism becomes reductionist limited to a fixed context or fixed ground rules and does not explore evolving context whereas prediction basically seeks to explore the evolution of the context.

But perhaps more useful than any epistomological test that we have mentioned and perhaps of the nature of a matatest is wht we might call the ratio of output to input in any epistomological construct. This could be something like the number of phenomena explained to the number of assumptions made. So this is a test based on economy and elegance. It involves knowing a measure of the degrees of freedom in a construct. We have in simple cases, problem of fitting n values with n free parameters. It is well known the different outcomes possible with having n equations and n unknowns.

We may take, for example, Kepler's Third Law It had a certain amount of elegance in that only two parameters were involved the semi-major axis of the orbits and the period in which the planet revolve. The total sample was small, however the ~~first~~ Kepler's Third Law proved predictive. Its original acceptance was perhaps because of its simplicity the fact it fit two parameters but it was also accepted because of precision although it was modified later with the introduction of a mass parameter. But above all perhaps because of its comprehensiveness. However at the time of ~~Ca~~Kepler his law was new and it could not be said to be tested against how it fit in to the know body of knowledge because the known body of knowledge was largely prejudice (such as prejudice that only circles were perfect and the world was made perfect). When we come to the ~~tidiest bold~~ Titius – Bode law we have ~~here~~ predictiveness, comprehensiveness, simplicity, but it involves only one parameter and it does not tie in to the known body of theory. Which of these later two reasons have militated against ~~Bold's~~ Bode's law as taking an important place is difficult to say.

~~With those task~~ we ask why are certain hypothesis accepted or rejected. If we were to give in order of increasing importance tests for hypothesis we may list them as follows:

1. Do they tie in with the existing body of knowledge; i.e. are they consistent and analogous.
2. Are they predictive
3. Are they comprehensive

model

4. What is the level of precision
5. Are they elegant or simple.

It is well to note here that there exist certain differences in hypothesis involving continuous formulations and those involving discrete ~~relations.~~ formulations. In the first place ~~fifths~~ fits in the continuous distribution involves two or more parameters. There are many values to be fitted and consequently many ranges that can be ~~trusted~~ tested. On the other hand the discrete ~~or~~ are limited to a few values to be tested and in general the data is more restricted. But most important discretness ~~use~~ is possible in a one parametered distribution. In other words the discrete distribution may stand on the basis of one parameter ~~can not~~ and be independ ~~upon~~ ent of any correlation.

EPILOGUE - CONFERENCE ON METHODOLOGIES

It is a twentieth century truism that science and technology serve to increase man's control over his environment. This truism, like its nineteenth century predecessor, that progress is inevitable, may turn out to be more illusory than factual. Certainly we have witnessed an extensive increase in our capability to manipulate the environment, the speeds with which we traverse oceans, continents, the power per capita available for performing mechanical chores, the data that can be processed in minuscule times, are all satisfying examples of our increased capabilities. But we are also witnessing events that question the existence of our control of the environment; wide spread power failures, leaving millions of people stranded in cold and darkness; traffic paralysis, costing thousands of man hours daily; city air, polluted to the extent that it is unhealthy to breathe. "Man is confronted with powers apparently created by himself but which he cannot control," is Carl Jung's evaluation of the situation.

Early this year, the world's largest oil tanker of 120,000 tons was wrecked off the east coast of England, releasing thousands of tons of crude oil which floated ashore and polluted hundreds of miles of shore line. This developed into a tragedy that assumed national proportions in England. It is estimated that extensive portions of beach will be polluted for decades, perhaps even permanently. Since the feedback on the ecology of major environmental alterations of this sort are sometimes delayed, the full extent of the damage created by this more or less permanent pollution probably will not be evident for some years. There was widespread comment on this disaster, focussing not on the navigational mishap which was the immediate cause of the wreck, nor on the feasibility of constructing large tankers (they are quite feasible - there is a tanker of 300,000 tons currently under construction and one of 500,000 tons on the drawing boards) rather comment focussed on the defects in a technology that could blindly and blandly set up this sort of disaster. This isolated example made the ~~uncontrol~~ negative aspects of technology visible to many for the first time. One of our own Cabinet officers commented, "The environmental backlash we confront today cannot be eliminated just by applying more of the same science and technology that put us in our present predicament."

Jung's observation may be true that, "The very objects and methods which have led civilized man out of the jungle have now attained to an autonomy which man sees no ways and means to cope with; machines, methods, organizations, etc., have become even more dangerous than were the wild beasts." We may indeed have created forces and systems over which we have at best partial, inadequate control, but some of us feel that this situation may not be beyond man's means to cope, and that our present difficulties are traceable more to a short sighted unbalance in our applications of technology and to undiscerned prejudices within the scientific approach, than to "a jungle in our unconscious which we project on the outside world." In any event, the time has come to ring the bell on an era in which technology ~~is~~ has been applied without responsibility to the environment, an era in which complexity ~~is~~ has been synthesized without regard for social and human balance, an era in which change ~~is~~ has been continuously injected into society without there being a meaningful directive or goal. We must face the very great responsibilities of what we choose or do not choose to do with our technological capabilities, since we have reached the precarious level of technological development in which we have the power significantly to alter our environment without having the power totally to control the means by which we affect the alterations.

Among the prejudices which affect our approach to the applications of technology is the basing of decisions solely on feasibility. One of the severe deficiencies in the present application of technology is the failure to note that at some level of the state of the art the answers to the two questions: how big can we build a tanker, and how big should we build a tanker,begin to diverge. For decades technology has been primarily concerned with finding ways to do things hitherto impossible. The emphasis has been on pushing back the limitations of nature and ignorance in order to make more products and activities feasible in order to broaden our spectrum of choice. In an increasing number of technological areas we have recently moved from a regime of finding a way to a regime of choosing the best way. The task is no longer to remove natural limitations but to set up new limitations of our own, to define the constraints and restraints which are prerequisite to a sensible choice. In a regime of limited capability, choice is naturally made to the limit of feasibility; however, the habit of thinking developed in this regime, tends to carry over into the second regime. The difficult problems of choice are being ignored with option still being made for the limit of feasibility.

For example, in typical past wars the level of tolerance to destruction and ability to recover was higher than the level of any enemy's capabilities to destroy. However, in the past two decades, this inequality has been reversed. It is now possible to destroy beyond any nation's tolerance to absorb. We have entered a regime of choice of the necessity for limited and restrained actions, but some spokesmen still hold to the first regime thinking, confusing so called obligation to power with obligation of power.

Although this phenomena of regime change seems tautological to many, and is well understood by many business and government leaders, the oil on the beaches bears witness that one of our problems is to spread awareness of the regime change and up date the decision making process and to replace feasibility thinking with the powerful method of logical tools that are now available for making difficult decisions. In the second regime it is necessary to formulate every problem, not only in terms of the internal capability parameters, but also in terms of the contextual parameters, considering and exploring all the interrelationships and synergistic developments. This brings us to a second prejudice - our prejudice in favor of the reductionist approach as against a wholistic approach.

We had best rapidly acquire the techniques for living in a second regime culture for the new developments in biology are leading our capabilities to a level where we may shortly be able to determine sex, extend the life span and even create new varieties of organisms. Clearly the responsibilities of choice imposed by such developments are likely to be as demanding as any ever faced by man. Temptation to be guided by feasibility, say in producing selective viruses, could put an end to the human race.

In speaking of the inadequacy for the future of "the same science and technology that put us in our present predicament," there is implied the need for a new type of science. In one sense, the call for a new type of science is meaningless, for there is, and can only be, one type. With regard to the canons of verifiability, the tests applied to hypotheses, models, in order to reject them or give them status but not necessarily tenure as scientific knowledge, this is true. However, with regard to methodologies available for solving complex problems, classes of phenomena amenable to scientific investigation, methods of generating hypotheses, and elimination of hidden epistomological prejudices, a new science is needed. Some of us think it is possible (when one thinks of the difficulties of treating in a scientifically satisfactory manner isolated or single incidence phenomena and phenomena for which only a very limited sample can ever be available, then an extension of the canons of scientific verification is also desired).

Thesis

The Problem of Identification

The ~~objects~~ symbols of theory must be uniquely identifiable with the objects of observation. If, for example, we observed a diameter, the identification is clear and we could build a theory using these diameters. We can even dervive other symbols such as a potential, q. This q has a set of properties which we in turn look for in the real world. But as is the case in the quantum theory where derivative symbols called probability densities result, we can't identify these in the observables, ~~xx~~ we can only identify derivatives of E such as energy levels. In the Edelen theory, ~~fixxxxxx~~ there is the assumption that a jump discontinuity in the energy-momentum tensor. This infers a surface of closure and hence an entity. What is the entity? All we really know is that from this theory a set of properties, r, results. with the property of length, but there is no predicition of size. Our question is what is the minimum sufficiency on the set of properties of suspected corresponding objects to effect an identification? There must be:

1) a dimensionality identification,

2) a value identification, and

3) a pattern identification.

In other words, are the properties of the theoretical, r's and the observed, d's similar enough to be identified?
If we find some entities that obey the pattern, n(n 1) and have the dimensionality of length, then maybe there is a correspondence, but we do not know what size these are.
They could perhaps be molecules, not galaxies.

Our observational problem is to show that the properties of the set, $\{d\}$ are the same as the properties of a set $\{l\}$ of idealized diameters. We note that the properties of $\{d\}$ are defined in terms of operations performed on photographic images, photoelectric tracings, etc. and that the properties of $\{l\}$ are inherited properties from other theories, that is, they are abstractions of concepts of length. The real reason for writing this book is to clearly explain these problems. One basic problem is what set of properties between the set $\{r\}$ from the Edelen theory and the set $\{d\}$ from observation exist to satisfy conditions of identity. Observationally we can dervie properties from the $\{d\}$ and theoretically, we can manipulate sysmbols, but we do not have an identification until there is sufficient overlap between these and even then, the identification may not be unique.

Let us begin with a set of measurements $\{d\}$. How do we convert $\{d\}$ into $\{l\}$, i.e., how do we correct, calibrate, etc. DeVaucouleur*) discusses this problem and gives a list of about

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twenty things that can produce systematic errors in the measured diameters of galaxies. This is a meaningless exercise however unless we know clearly what the basic properties of $\{l\}$ are. For after we have made all the corrections we can think of and have obtained a set of corrected diameters, $\{d_c\}$, how do we know that the properties of $\{d_c\}$ match the properties of $\{l\}$?

The principle property of (1) is what we call the metric property, i.e., its appatent size (angular diameter) is inversly proportional to its distance. But here we are dealing with another unknown. Namely, the properties of the sapce in which these diameters are embedded. We don't know that the angular siaes vary inversly as the distance in this space. So we have no definition of a l, in fact, we know that apparent angular diameter not only varies inversly with distance, but that size of distant cosmic objects also depends on some unknown factor of the redshift, z. Actually, the determination of distance itself is through calibration of redshifts, so the l's turn out to be unknown functions of z's.

With all of these uncertainties, the question is can an identification be made? If the f(z's) can be determined through other observables such as magnitudes, we dould then define the l's and calibrate the d's. In this book, we haven't solved this problem, but at least we know that is what we're up against. We know the problem exists. The observational problem of the question of discretization is an identification problem. Are the objects we observe endowed with properties that result from the theory sufficiently mathhed to say we identifed discretization?

Theory