METATAXIS
SEMINARS
1963-9

CONTENTS METATAXIS

MEMORANDUM

TO: All Intrested Persons
DATE: 12 January 1969

FROM: Al and Donna Wilson

SUBJECT: Seminars on Metataxis

In view of the increasing need for new and alternate methodologies to identify, select, formulate and solve interdisciplinary problems of all sorts and degrees of complexity, we are organizing a series of seminars to be held on Thursday evenings (4:30 to 6:00 pm) at the Advanced Research Laboratory conference room. The format will follow a presentation - amplification mode. Each evening one topic will be introduced in the first 45 minutes and the rest of the time will be taken for group participation in amplifying and synthesizing. A brief description of the subjects to be covered in these seminars is attached. Below is the schedule for the first two series of seminars:

EPISTEMOLOGICAL FOUNDATIONS

23 January: The Frontiers of Epistemology
30 January: Structure and Process
6 February: Genera of Abstraction

ATOMIC - COSMIC RELATIONS

6 March: Methods in Quantitative Equivalence
13 March: The Cosmic Diagram
20 March: Atomic/Biological/Cosmic Clocks
27 March: Alternate Concepts of Space and Time

Future dates for other series of these seminars will be scheduled in the near future. The amplification mode limits the size of the seminar to no more than 12 people. If you are intrested please call Donna Wilson before 20 January to reserve a place in the seminar. Since each presentation builds on the previous seminar, we urge that you plan to attend all sessions in any one series.

Al and Donna Wilson
phone: (714) 893-6351 days
(213) 455-1764 evenings

Handout - 1
6 Feb 1969

RECAPITULATIZATION: SEMINAR I and II

Albert and Donna Wilson
Seminars on Metataxis
Huntington Beach, Cal

Seminar I
23 Jan 1969

DEVELOPED

- Epistemology in the Barricades
  not in the Ivory Towers
- Technological Backlash
- Procedural Modes of Technology
  1) Do what is feasible - without regard to context
  2) Develop products/systems randomly - without regard to their cummulative affect
- Epistemological methods derive from:
  - Aristotle - deduction
  - Bacon - induction
  - Descartes - spacial constructs
  - Newton - temporal constructs
  - Locke - reductionism
  - Pierce/James - pragmatism
- Cognitive Processes: ability to
  - recognize same or different;
  - recognize patterns;
  - map or manipulate symbols.
- Weber/Fechner Law
  - frogs boiling
  - perception of change

TO BE DEVELOPED

- Classical Bases of Knowledge:
  - Plato - Recollection and
  - Kant - Critique of Pure Reason
- Cognitive Processes
  - Relation between differentiation and pattern recognition; Mill's - going from order to measure.

Seminar II
30 Jan 1969

DEVELOPED

- Limitations of Scientific Method
  - Intrinsic
  - Habitual
  - Prejudice

- Strangeness/Credibility Diagram

TO BE DEVELOPED

- Structure of Scientific Method
  - Nature of Phenomena
  - Hypothesis Formulation
  - Hypothesis Testing
- Extension of Present Techniques
  - Cognition Spaces
  - Paradigmatic Inference
  - Analogy/Homology/Parataxis
  - Amplifying-Deviation Feedback
  - Whitehead/Hilbert Approach
  - Detection of Limits
  - Observables versus Descriptor
  - Paradoxes
  - Explanation vs Understanding
  - Double Frontier Hypothesis
  - The Third Revolution
    - First: Energy
    - Second: Information
    - Third: Imagery
  - Epistemological Strategies
    - Theory Directed
    - Search
    - Pattern/Rules for Generatin
- Extension of Theories of Knowled
  - Plato
  - Kant
  - Eddington
  - Jung

SEMINARS ON METATAXIS*

SERIES I EPISTEMOLOGICAL FOUNDATIONS

23 January Frontiers of Epistemology: An Overview

Basic cognitive processes. Classical epistemological canons, their limits and prejudices. Possible directions of extension, new relational calculuses, Paradigmatic inference.

30 January Structure and Process

Entity and relation. Processes and rates. Topological and temporal closure. Modular and propagation velocities.

6 February Modes of Abstraction

Levels of abstraction. Myth and Math. Signs and Symbols. Analogy and Homology.

SERIES II ATOMIC - COSMIC RELATIONS

6 March Methods for Quantitative Equivalence

Quantitative equivalence. Precision, Prediction, Paradigmatic efficiency. Dimensional analysis.

13 March The Cosmic Diagram

Constants of Nature, Dirac's Principle, Potential Limits, Discretization, Resonance.

20 March Atomic/Biological/Cosmic Clocks

Basic periodicities. Rules of Combination. The endogenous clock. Geophysical and Biological cycles, Inferences.

27 March Alternative Concepts of Space and Time

Leibnizian view versus Newtonian view. Cartesian and non-Cartesian spaces. Linear and cyclic time.

FUTURE SERIES

Techniques for Synthesis

Epistemological Systems

Methodologies for the Social Sciences

Science versus Systems

Scientific versus Axiological Constructs

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* Metataxis from meta= beyond or outside and taxis = structure or organization. The discipline concerned with the identification and organization of the properties and relations common to various general classes of structures and processes. The nature of the laws governing what is possible in structure and process. Structure and process viewed from several levels of abstraction.

SEMINARS ON METATAXIS*

SERIES III METHODOLOGIES FOR SOCIAL SCIENCES

8 May Display of Pattern and Relation in Social Data

Differences between classification displays that serve retrieval functions and relational displays that reveal intrinsic structure. Relational displays as theoretic forms that provide hypothesis-generating capability.

15 May Introducing Value in Factual Structure

The structure of Gandhian Nonviolence as an illustration of combining normative statements with descriptive statements of human nature to derive levels of increasing specificity.

22 May Search for Structure in Social Phenomena

What are the salient relations that structure society at all levels and how do these derive from the human psyche. What is the nature of these relations. A holistic approach to focus on elements and linkages contained in social situations.

29 May Epistemological Problems in Soft Sciences

Difficulties peculiar to structuring complex phenomena found in social and psychological realms. Differences between methodologies based on quantitative measure and methodologies based on relational constructs. Extending the class of content-free (formal) structures through study of content (factual or axiological) structures.

Time: 4:30 to 6:00 pm Place: Advanced Research Laboratory

phone: (714) 893-6351 days
(213) 455-1764 evenings

Al and Donna Wilson

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* Metataxis: from meta:beyond or outside and taxis: structure or organization. The discipline concerned with the identification and systematization of properties and relations common to various general classes of structures and processes. The nature of the laws governing structure and process. Structure and process viewed from different levels of abstraction.

SEMINARS ON METATAXIS

The past quarter century has brought us awareness of a growning *technological backlash*. No longer can we equate technological advance to progress, where progress is 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 is characterized by two procedural modes: Doing what is feasible or possible with secondary or no consideration to whether it is useful or needful; and Developing products and systems in a random manner isolated from contexts and without general plans — without regard to their relevance, to human goals, their affect on the ecology or their accumulative interaction with each other. This reductionist approach results in an uncontrolled evolution whose emerging creatures are, at minimum, unbalanced and absurd and, at maximum, pose grave threats to human health and survival.

In the choice of what scientific problems to solve and what technological systems to build, feasibility and reductionism have spawned a set of new problems — super weapons, polution, congestion — that reductionistically oriented science and technology cannot solve. This situation is unacceptable, but its causes have not been rejected. Even in the approach to the problems created by the random application of technology, the same random and reductionist philosophies prevail 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. To counteract the unleashing of violent forces through widespead use of drugs, we support research for crime detection and impose stricter laws and enforcement. 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 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 the causes of our problems stemming from the level of our most basic view of the world. The proud heritage of Western thought has been tested in a new millieu of its own creation and it does not work. Even the things that we know best, are most sure of, and feel we never need question apparently contain errors of consequence. 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 but also 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. 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 denial of phenomenological sectors of our 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 our favor is the fact than an auto-homology exists between our goal and the path we must take to reach the goal.

Albert and Donna Wilson
12 January 1969

A. G. Wilson, 5/2/6

METATAXIS

I. INTRODUCTION

Man as part of nature shares in the universal drive to order or structure experience and data. We are aware of the existence of some sort of order or relationship between all of our experience and all of the phenomena that we observe in nature. The history of human thought centers about the mainstream of the processes that man has designed by which he can place order or structure into his experience, by this experience sense data, or the data from sophisticated instruments, or simply a mass of folklore. We hopefully are able to design a structure for our own experience which represents an isomorphic map of the structure that nature itself uses. A structure that comes close to this ideal of isomorphism is the structure that has been built by science. However, the structure that we can impose upon our data and experience is not unique (we are not sure whether the structure used by nature is unique). Experience shows us that is is possible to structure in alternative ways so there may not exist a unique structure for our knowledge, although there may exist an optimum structure. The history of mathematics shows that we may synthesize many structures but only a few of these are isomorphic to the structures which exist in nature.

The elements that go into our structure may be data of different levels, perhaps merely numbers, perhaps propositions, perhaps theorems, or perhaps even sophisticated substructures. There are two approaches to the operation of structuring; the classical approach may be called the epitactic approach. In this approach new data is operated on with a classical body of theory in order to incorporate the new data into the existing structure or body of knowledge. If the basic structure is a good structure, it will be able to subsume epitactically the new data which is brought to it. Frequently, however, it is necessary to destructure part of the existing structure and to restructure in order to incorporate the new data. For example, the introduction of the quantum hypothesis by Max Planck was a destructuring of a large part of physical theory in order to accommodate such new discoveries as the photoelectric effect and the nature of atomic spectra.

As an alternative to the classical method of destructuring and restructuring, it is sometimes necessary to start ab initio and to take the basic data or experience and create a structure from the ground up; in other words, to ignore any existing body of theory and try to derive a theory on the basis of all of the data which is presently available. Whenever an existing body of theory runs into profound difficulties and is not able to incorporate new experience or new data, destructuring may be useless, and it is necessary to completely start ab initio. We have, for example, the institution of Synanon. Whereas existing institutions were of only limited effectiveness in curing drug addiction, Synanon beginning ab initio with new concepts was able to create a new structure which has proven quite effective in curing and rehabilitating addicts. It was not possible to start from any existing institution or with any existing theories concerning how to cure addicts and to have arrived at the success which has been achieved by Synanon. In our time, there is increasing evidence that many of our institutions are not capable of handling the new experience and the new data which is coming in increasing floods. There is some question of whether the system of public schools, for example, can be used at all as the proper way for passing on through education of the race. The operation of beginning ab initio in creating a structure is orders of magnitude more difficult than the operation of destructuring. Accordingly a methodology or set of operations by which such a structure can be formed must be derived. It is the purpose of the present discussion to enumerate different methodologies by which structure may be introduced into an existing body of data without reference, or with minimum reference, to an existing body theory. Implicit in both methods, destructuring and restructuring which we may term the epitactic method, and in structuring ab initio which we may term the metatactic method, is the concept of change. Both the epitactic and metatactic methods are examples of the dynamical processes of change. The former may be considered a continuous or step-wise change, the latter a catastrophic or mutative change. The dynamics of change may involve a change on the level of the structure or a change on the level of the governing code which controls the structure. Both of these forebode epitactic and metatactic methodologies. Alfred North Whitehead said that the challenge of the twentieth century was to allow for change within a framework of order and to preserve order within a dynamics of change. Epitactic prophesies permit the preservation of order and step-wise change. Structuring ab initio is associated with a reversion to complete chaos as would occur after a catastrophic revolutionary event. But since we are not immune from catastrophic destruction, it is well to study methodologies by which we can structure ab initio.

METATAXIS II

Common to all metatactic methodologies we start with a set of questions:

1. What are we trying to do?
2. What resources do we have to do it with?
3. How do we go about doing it?

The first two questions allow a large range of specifics. The third question possesses commonality spanning many specifics and accordingly, can be abstracted. It is the purpose of this discussion to focus on those properties of question three which may be abstracted.

In addition to the three questions, there exists a set of constraints under which the solution must be derived. Some of these constraints are known, some of them are unknown. Some of the constraints are implicit in the nature of structure or its context, some of the constraints are added at our own preference. An example of the former may be a limit of the size of the structure. An example of the latter may be a habit in our thought that we are not aware of. Some of these constraints may be at odds with what we are trying to do and may even preclude a solution unless we are willing to abandon these constraints. For example, we are not able to solve certain problems by means of existing institutions. The existing welfare structure, for example, does not allow us to solve the problems of rehabilitation and aid to poverty stricken peoples. The present structure proliferates the problem. Another constraint is the demand that Whitehead made that our change be made within a framework of stability. Nature employs both types of change, mutative changes and step-by-step changes. We must permit ourselves both types. In a transportation system, for example, we normally make step-by-step changes, designing the next generation of vehicles and of the system from the experience of the existing system, and introducing minor changes, keeping the present system intact. However, the time comes when the system fails and it is necessary to structure a new system ab initio. This is very difficult, especially when we have to abandon components of an old system which have been laboriously put together at great cost over large periods of time. It is this reluctance which is a constraint which forbids our plunging into the search for an adequate solution which can solve the problem in its full force and aspect.

In order to study this very important problem posed by Whitehead, when we must ask when is it possible to have change and stability; in order to discuss this question we must first define what we mean by stability. In general, stability means that the bulk of an existing structure is maintained in a functioning condition while processes of destructuring and restructuring are being incorporated. Destructuring and restructuring modifications can be performed without discommoding operations provided that the timing of such operations is interleaved or phased with the metabolic operations of the system. For example, a freeway can be closed completely between 1:30 and 3:30 in the mornings and major operations that can be performed in a two hour time may be undertaken without discommoding the primary function of the freeway. What is important in this is a recognition of the time constants and phasing of time that are involved.

Every structure has associated with it a characteristic of time or a time constant. Men have several characteristic times associated with their organic structure. The most basic of these characteristic times is the metabolic time of 24 hours. There are also periods of 28 days, 11 years, and 80 years associated with human life, if the latter may be considered typical of the life span itself. Some structures such as a mountain range or the Grand Canyon have characteristic times of great length. In fact, their characteristic times are so great that for purposes of man as an observer with a short time constant, these configurations appear to be static. Their changes are imperceptible to us. What is of importance is the relative characteristic times of the object observed and the observer, or of the relative characteristic times of the components of a structure and the structure as a whole; a city, a nation, a civilization has a characteristic time that may exist for several centuries, and for purposes of an individual human these institutions may appear to be essentially static.

In our time many institutions and circumstances appear to us to be accelerating or to be changing more rapidly. As far as we know, our own characteristic times are remaining constant; so what is happening is a relative change in the characteristic times of our cities and cultures with respect to ourselves. In nature it is observed that characteristic times are associated with mean densities and part of the acceleration of a characteristic time of a city, for example, may be associated with the change of density.

Ouspensky points to four kinds of relative motions. Type one is like the hour hand of a clock; we observe the hour hand but we do not see any motion, but coming back later, we see that it has moved. Type two motion is like the second hand of a clock; we clearly see its change of position as we stand and observe it. Type three is motion like the apparent linear motion of a lighted match that is moving in the dark rapidly; it no longer appears as a point source of light which it really is, but appears as a line. Type four motion is so rapid that the observer does not even know that it has taken place. We may think of the spokes of a spinning bicycle wheel as an example; the wheel may be static and we clearly see the spokes; it may be moving slowly and we can still follow the motion of the spokes; it may be moving rapidly so that the spokes disappear and their presence is known only if we attempt to throw a rock into the wheel and see that the rock is reflected instead of passing through the wheel. A table or piece of solid matter is like the rapidly spinning bicycle wheel in that we are unable to penetrate because of the rapidity of motion.

It thus follows that the concept of static has to do with a difference between the characteristic periods of a structure and the characteristic period of the observer. It is not necessary that the characteristic period of the structure be very large compared to the characteristic period of the observer. The appearance of stasis also comes from the characteristic period of the structure being very short in comparison with the characteristic period of the observer. Knowing that change is fundamental to all structure, we have now a suitable definition of a static, or rather an apparently static structure. That which is apparently static can be explained in terms of large difference between characteristic time of a structure and characteristic time of the observer.

Whereas physics has long tried to remove the observer and all elements of the subjective from its considerations, it has run against difficulties, especially in connection with its investigations in the area of the microcosm. We prefer to leave the observer into the total considerations, taking into account his time constant with respect to the time constant of the structure. The success of physics in being objective may perhaps be due to the fact that a decoupling exists. Whenever the time constants of two structures are different, accordingly if the time constant or characteristic time of the observer is different from that of the structure that he is investigating, he will be largely decoupled from that structure; and decoupling in effect removes the influence of the observer from the structure observed, and this is what is meant by objectivity. The success of physics, therefore, in claiming objectivity is due to the fact that the structures observed in physics have a markedly different time constant than that of the observer. A curious situation, however, arises in connection with a study of the microcosmos as enunciated by the Heisenberg principle. If decoupling exists only when the characteristic periods are different, it must be that there exists a characteristic period of the observer which resonates with the characteristic period of structures on the scale of an atom. This coupling because of the similarities of the characteristic times of a human and an atom is manifested in the Heisenberg principle. Calculations indeed bear this out since the characteristic times of atoms and humans are apparently closely related.

Another interesting feature of the decoupling which exists whenever two structures have different characteristic times is the achievement of privacy. Privacy can be effective by a decoupling based on changing of a characteristic frequency. Since only those structures operating at the same frequency are in tune with each other and resonate, a detuning, so to speak, should provide for privacy. One sees this even on the freeway where the characteristic time of the mode of travel is decoupled from the characteristic time of the city as a whole through an on-off interface providing a high degree of privacy on the freeway.

Classically we examine the validity of knowledge in terms of certain types of tests. These tests may be based upon inductive and deductive canons and through various types of inference, being ultimately based on observational or experimental verification. A great deal of our knowledge is the structure of actual information through the fundamental rules of logic and inference. We may also find it quite useful even without having tests available that under the classical approach would be considered as adequate means of verification, a structure of factual knowledge, which may not be epitactically relatable to the major body of knowledge but still be of important use. If a structure containing a great many pieces of factual knowledge can be built according to a small number of rules, then such a structure may be considered knowledge and is useful through its economy of representation even though all tests for its objective validity may not be performed. We call such a structure of knowledge a paradigmatic structure derivable from paradigmatic inference. If through the assumption of two or three postulates, we are able to fit a large number of facts, then we feel that such a structure or substructure is an important part of the overall epistomology even though its connections with the structure which represents the larger classical body of knowledge may not be perceptible at the present time. We take as the test for its usefulness simply a high ratio of facts contained or explained by the structure to the number of assumptions that go into the structure. Even when there exists a contradiction with certain portions of the existing body of knowledge, the substructure will be useful if the ratio of output to input is high because economy of representation is in itself a most important facet of our structure.

D. S. Wilson, 1/7/69

The object of any systematic thought and effort is to organize the objects of study into a meaningful whole. If carried f~~o~~ar enough, the result of this organization becomes a theory or model and if realized, it has the property of abstraction. By abstraction we mean one can obtain further detailed explanation of like phenomena by utilizing this theoretic-form.

In studying phenomena, we first ask what entities exist that need to be organized into a meaningful whole. What elements serve as building blocks to construct a theoretic-form. We have experiences of social phenomena, both personal as well as historical. We also have experiences retrieved from previous study of social phenomena, as well as experience reaped from experiment in social arrangements and organizations. And certainly as individuals, we possess sufficient experience (common-sense awareness, if you like) of the social context to to be able to survive within the social milieu. But if we are to propose alternatives or modifications to this current context and if we are to evaluate proposed alternatives, we need more detail than these diverse bits and pieces of experience. The notion of inventorying, describing and discovering relationships between the elements of social experience is the subject of this paper. Our objective is to describe a collection of social phenomena items and to show that a subsequent organization of these elements both contains what has been collected and will accept further collections as well as offer guidelines in evaluating proposed alternatives to our social milieu.

The elements that we seek to organize are bits and pieces of experience. We assume that we will be able to include all experience humans are capable of experiencing, that is, past experience, anxiety or projections of the future, controlled experience from the laboratory as well as experience within and without socially institutionalized structures. One of the most difficult steps at the onset is deciding how to describe the elements. Obviously the inputs to our theoretic construction must somehow be made compatible. It is not immediately clear how to find patterns of regularity among such diverse elements as the brain wave recording of a subject in a laboratory, the results of controlled experiment in social dynamics, the content of a poem, or the experience of riding on a freeway.

Description involves language and here we encounter all the difficulties of grammar, semantics, and other public transformation. Yet it is ridiculous to seek mathematical description of our elements before we can bring some order into a natural language description. Unfortunately many efforts at theory building in social science do not concentrate enough on this first step of description -- the resultant theoretic-forms display this omission.*

Although description is crucial to establishing any possibility of finding patterns of regularity among the elements, it is not the first step in choosing elements to organize. It is not the <u>first thing</u> an investigator does because at the beginning one does not have a priori insight into what to collect. One begins an inventory of interesting things long before he knows how to describe <u>what</u> he has collected. But in communicating results of a study, an investigator tries to make a logical presentation of what he did (step B follows step A, etc.).

THE INVENTORY

Over the course of this study, we have collected a file of items relating to social phenomena. In their original form, this file consists of notebooks full of reports, published papers, newspaper clippings, citations to the literature, handwritten notes from lectures, interviews and mass-media programs, book reviews, etc. Each item is given a retrieval number and filed into a 8 1/2 x 11, three hole notebook. The only criteria for entry into the file is that it conform to this

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size -- entries that are off-size are cut and xeroxed to fit. This inventory, now consists of over 400 items and it is open in the sense that addition of entries can continually be made. A rough subject and author index that correlate similar items existsas a working tool.

DESCRIPTION

In addition to the original source file, there now exist two forms of abstracted content-- one, on 3 x 5 inch cards and the second on 2 x 2 inch tags. Here the physical size limits the size of the abstraction and forces the description of elements into somewhat compatible form. What we have discovered in the course of various team effort to categorize and organize these cards or tags are several characteristic sets of relationships. Drawing upon the notion of symbolic logic, set theory and Boolean algebra we find it is possible to write a description of all the items in our inventory in one or more of the following formats:

Equivalence:	a equals b
Limited: Control	a dominates b
Contain~~ed~~:ment	a contains b
Tendency: or Trend	a inhibits/enhances b
Temporal: "causal"	a precedes/follows b
	a balances, or complement b

cf Juduko
07-12-11

EPISTEMOLOGICAL FOUNDATIONS

I Frontiers of Epistemology: An Overview

23 January 1969

One of the things we hope to overthrow in our revolution is the tradition of the Royal Society of London. Since about 1640, the Royal Society determines the format in which everybody has a seminar. It starts with a real stuffy lecture and goes on for about an hour, then people try to one-up the speaker by calling attention to flaws or omissions or by pointing out that everything he said was just a special case of something else that is more general or profound. This format has been modified somewhat in this country; it's not quite as severe as it is in England. But we want to get away from this format. We want to introduce a format in which we'll give a block of ideas or material and then turn to a type of discussion we call amplification. Amplification requires that we stick to the subject. You could develop it according to whatever lines occur to you, but we don't want to go off in directions completely unrelated to the central core of ideas. Amplification is not free association.

We plan to give two or three blocks of material each evening with amplification following each black. Any questions of clearification, definitions and so on, please interupt at the time. Any questions of development, hold until the end of the block when we'll have a few minutes of this type of amplification. At the end of this, if it looks as though it could go on and on and several exciting new ideas come out, then we will take it up in more detail at a later seminar. We do want to stick to a general theme which underlies these ideas. We hope to stay focused without becoming stiffled. As we go along we will correct each other on this method, if we can.

We're calling this first seminar, The Frontiers of Epistemelogy. Nobody is particularly excited about epistemology.

It's an ivory tower subject. But it has suddenly become a real world subject. It is really in the barricades at Berkely, Columbia, Paris and Prague. Epistemology is that relevant, whether people know it or not. What's going on in the world today is to a large extent is a revolution that is against our present way of thinking about the world. Now the dominant way we think about the world today in the Western world is the scientific way. We're very proud about our scientific way of thinking. We struggled for centuries to get it. About two hundred and fifty years ago we finally became emancipated when Francis Bacon formulated the inductive canon, and since then we've thought there could be no limits to the heights we could fly with our scientific method. But a revolution is in progress denouncing this method as being defective and de-humanizing. And I think one of our first tasks here is to investigate this — to look at what some of these people are saying and to see what bearing it has on science.

Now really this attack is against all our current institutions but underlying this is our so-called scientific way of thinking and we have to look at that in a little more detail. People have referred to 'white backlash and black backlash', but in the past quarter century there is an increasing awareness of what we could call the technological backlash. Technological backlash takes the forms of polution,congestion, and these super weapons that threaten us —things that have been created by science and technology. It has come to the point that we can no longer make the bland statements, some people are still making them but they are not meaningful, that technological advance leads to progress where progress is measured in terms of welfare, happiness and self-realization of human beings.

In all of this search for control over nature, we succeeded in unleashing many forces of nature that constrain us and threaten us. The youth see this and say, "You know, I don't know what you're talking about when you talk about the good life flowing out of science". Technological advance in our times is characterized by two procedural modes. First, we do what is feasible. We do what we can do with no or only secondary consideration for whether it makes sense, whether its useful or needful. We build a tanker for example, of a hundred and twenty thousand tons -- its economical of course, but when it breaks up and spreads oil all over the coast of Cornwall then we realize in one sense this isn't right. It would be smarter to keep our oil in smaller modules. But the response to this is to go ahead and on the boards now, there are tankers of five hundred thousand tons and the Japaneese claim they can build one of a million tons. I'm not disputing the feasibility of it, I'm only using this as an illustration. We do whats feasible without regard to what really makes sense.

Now the second procedural mode in our technological culture is that we develop products and systems in a random manner, isolated from the context in which these products and systems are to operate. These are developed without a general plan that shows their relevance to each other or their relevance to human goals or without concern for their effect on the ecology or their accumulated interactions with each other. So how can one make a meaningful plan, if all the random things that others are doing is not predictable. You can't anticipate what they are going to be developing. So, people are now saying that technology has become autonomous. Its the tail that wags the dog.

We next encounter a term thats popping up everywhere, that is reductionism. One could say that technology uses a reductionist approach. We'll go into this in a little more detail later. But this reductionist approach as I'm using it here means we look at entities without concern for their relationships with other things. This gives us this uncontrolled evolution. The emergent creatures in this evolution at a minimum are unbalanced and absurd and at a maximum they pose very grave threats to both our welfare and our survival.

In the choice of what scientific problems to solve and what technological systems to build, this feasibility and reductionism have spawned a new set of problems, some of which I just mentioned -- polution, congestion and so on. But the feasibility and reductionistic oriented science and technology is incapable of coping with these problems. This is why the retiring Secretary of the Interior, Stewart Udal said that the same kind of science and technology that has put us into our predicaments today is utterly incapable of getting us out of them. Thats a challenge. Well, we find the situation unacceptable but we don't reject the causes. Even in the approach to solving these problems, for example the problem of airport congestion, we use the same random philosophies that made the absurdities in the first place. For exmple, we think we can offset the threat of ICBM's by building a whole set of ABM's which have fallout too. To overcome the threat of passengers that brandish pistols in airplances we suggest giving the pilots and stewardess' guns. And so on. The question is how are we going to find solutions that do not continue to contribute to the problem.

We've identified two villians then -- reductionism and choice by feasibility. These two things govern the unstructured allocation of resources and research energies which in turn govern the growth of our technology. We might ask, where do these ideas of reductionism and feasibility come from in the first place? The processes by which we think about the world have developed by a logical growth from some philosophical ideas that are very deep within Western thought. They derive from as far back as the epistemological canons of Aristotle -- the deductive canon, the whole ideas of deduction. They come from our ideas of space, largely from Decartes and the particular way he put together numbers and geometry. They come from the temporal concepts of Newton -- the idea of linear time, absolute space, absolute time. Just ask yourself, how do you measure time? Any system that you may design for measuring time involves something cyclical. Any clock you have must involve something oscillating. Time is cyclical, yet physicists treat time as something that is linear. Why do we persist in doing this when we know that operationally time is not linear? These are questions that we want to come back to in these sessions and see if we can't get closer to what these things may really be by erasing prejudices if we can. Next, we go into the reductionism of Locke. It was John Locke who was the father of reductionism, we'll spell that out in a minute. Then there is the thing that Americans pride themselves on most of all -- pragmitisism. This comes from Pierce and James. To say we're intrested in being practical, we're intrested in getting results, we ask does it work -- unless you say something about the time interval of feedback associated with your pragmaticism, you haven't really said whether you're practical or not. Sure it may work, for two years like our whole culture, but in twenty years the smog begins to move in on you and we ask, does it really work? Pragmaticism without the feedback loop is meaningless.

Its rather disconcerting, even staggering to see that the causes of our problems come from the deepest level of the way we think about the world. This heritage of Western thought which we feel is superior to everybody else's is being tested in a new milieu and it doesn't seem to work. Even with some of those things we know best and are most sure of, things we feel we never need to question may possibly have errors in them. What I hope we can do here in the next few weeks is to question these. Maybe they don't contain errors but its worthwhile to question things that haven't been questioned for centuries.

This revolution thats going on is going to have be conducted on a far more deeper level than any of the people who are now leading it realize. They see something is wrong and they want to knock it over, but they don't know what's wrong and they don't have any alternatives in mind. They are posing a very severe threat and as a response to that threat, we as scientists, as members of the establishment and members of the revolution both feel its our job to bridge this gap and find out what's really going on.

We do this by trying to become conscious of the tacit assumptions that underlie our most basic ideas. Then we want to look at alternate patterns of thought that may be available to us. And in looking at these alternatives, we may find where some of these tacit assumptions lie. One of the things we find is that the present system of science forces us into phenomenological denial. There are many phenomena which occur -- we can all name some in our own experience which when we talk seriously about them to colleagues encounter smiles and embarrassed giggles. Subjects such as ESP or UFO's are not tractable with the Baconian and Aristotlian canons. Yet they may be phenomenon of the natural world. How are we going to get a handle on them. One thing is to deny they exist except in the minds of crackpots and we will go into this as one of our fundamental problems to see if we can create new canons whereby we can treat such phenomena and decide whether they are illusory or whether there is some phenomena that we have not been able to tackle because we do not have the proper concept of space or time in which to even imbed a hypothesis.¶ Now we need a name for what we are doing here. After this description which looks as though we are covering everything, it is hard to find a name but we have picked one. We want to look at all kinds of modes for structuring experience, whether scientific or merely everyday experience. We want to develop logics and meta-epistemologies, so we have adopted "metataxis." Taxis is organization or structure and meta means beyond or above. So we are talking about the framework or the structure of structures and the processes of process and we will try to classify these different structures and processes and organize them in a meta sense. Now this is a tough philosophical exercise and we are going to have to forge our tools as we go. ~~and~~ We are getting into pretty largely unexplored territory and if there are any successes, they are going to be pretty difficult to come by. But the rewards, if any, promise to be pretty high. We have in our favor that an auto-homology exists between our goal and the path that we must take to reach the goal. I don't want to explain that sentence I will discuss it in great detail later.¶ Some of you may have seen this article in the January 3rd issue of Science by Don Price who is the retiring President of the American Association for the Advancement of Science. He mentions that science is currently being attacked on two fronts; the first attack is coming from the establishment, Congress, the tax payer — they all feel that science is not particularly relevant. In spite of the excitement of sending men around the moon, there is a great portion of the population that feels this is kind of an absurdity, an unbalance. That if we are going to spend the tax payer's good money, we had better spend it on something closer to home — let's get rid of the smog, an so on' There is in addition a kind of an economic retrenchment going on which our company and others are feeling; in fact, basic research and scientific research, private and public, is being squeezed throughout the country. But this is a reaction, not just a cycle of economy. It is a reaction to scientists not doing their philosophical homework. NASA, for example, has not explained what it is all about, and this is why people are not particularly excited about the moon flights. Now the second front on which this attack on science is being launched is this world wide rebellion that we have been speaking of. This is usually identified with "flower power" and the adolescent fringe on the street. The idealogies of this rebellion are such that they place themselves straight across the path of the goals of science. I quote here from Price, "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."

Now there are four major philosophical spokesmen for the new rebellion and it is worth mentioning, at least in a one sentence capsule, what they have to say. First we take Andre Malraux. He says the most basic problem of our civilization is that it is a civilization of machines -- that we for the first time have a knowledge of matter and a knowledge of the universe which suppresses man. Another spokesman for this New Left is Jacques Ellul. He is one of the foremost in pointing out the trend in which our technological society is moving. He has founded this Foundation of Futurables, predicting the technological future. He is not alien to technology, he is aware of it. He says, "Scientists have become sorcerers who are totally blind to the meaning of the human adventure." He further feels that a system of thought has come up in scientific thinking that is bringing about a dictatorship of test tubes rather than a dictatorship of hobnail boots. Another spokesman for the revolution is Erich Fromm. He says that technical progress has become the source of all values and we see in consequence the complete alienation and dehumanization of man. Perhaps the central speaker and philosopher of the rebellion is Herbert Marcuse and he has struck closest to the fundamental chord whose resonance spurs the dissent. He says this: "The mathematical character of modern science determines the range and direction of its creativity and leaves the non-quantifiable qualities of humanism outside the domain of exact science."

Now I think it might be a little more accurate to say that the type of abstraction that is used by modern science, particularly the reductionist approach to the world, forces the bulk of relations of a higher sort — the relations between man and the ecology, between man and man, between man and himself — to be left out of the models that are built. So I think it is wrong to call science the villian. It is something that is underlying science. It is the epistemological basis on which scientific thinking is built. Science is the victim along with a lot of other institutions. So this is really the rationale behind our getting together. This is critical, and as I said at the beginning, epistemology is no longer in the ivory tower — it is in the barricades. It is going to be important to be on the battle spot of an epistemological front and we had better find out how to draw the lines for these battles.

Now it is interesting that scientists themselves are becoming aware of these pitfalls and dangers in the reductionist thinking. There are many scientists who are convinced indeed that we are building a very dehumanized world. I don't think that needs any comment.

Let's look in more detail at this reductionist system of thought. It derives primarily from the works of John Locke, about 1680 or somewhere in there. We can summarize it pretty much as follows: Lockean reductionism operates in at least three ways. You take what is small and molecular as being more fundamental that what is large and molar. What is external and visible is more important than what is not. Finally, what is earlier in development is more basic than what comes later. Now to anyone who has been brought up and educated in the West in the last fifty years, this just sounds like the most common of commonsense. You mean there is something wrong with this? Paul Weiss updates the doctrine of reductionism. He says "reductionism axiomatically prescribes all the relevant macro-information about nature; it must and eventually will be derived completely from adding up and piecing together the micro-informations about the smallest sample units." So reductionism is a system of thought that stresses analysis and looks for the explanation of every phenomena by breaking it down, dissecting it and looking at the constituent parts. It feels that the flow of causality is from the small to the large. So if we are going to explain the earth's atmosphere, we take one cc of air and analyze it in every possible way by breaking it down. If we are going to explain the water drain out of the tub, we describe the dynamic flow of the spin that it has in terms of equations of continuity and various equations. This is, of course, immediately ridiculous; but there are other examples that are not quite so obvious. You have to take into account If you are going to explain water going out of the tub, the fact that the earth is rotating. You have to take into account the context in which the system is imbedded and this is what reductionism is not doing. It does not look at context — it does not look at relationship. A car is designed on the basis of how it operates, NOT on the basis that drivers must look out and not have blind spots to see other cars on the freeway. We design our water drainage systems here in California for the conditions of average yearly rainfall NOT on conditions of flood for three days a year and drought for the rest of the year. We don't look at relationships. We don't see how one thing could affect another because each of us are trained as analysis. We are trained to dissect things and focus on them in more and more detail with higher and higher accuracy and precision. We wear ~~are~~ blinders to parameters that reveal the whole. Well, that's reductionism.

Since the world is getting more crowded and the interrelations are becoming more intense between all facets of society, contextual relationships begin to have a lot higher relevance. The failures of this reductionist approach becomes more visible to us. One difficulty in changing from reductionism to something else is that we don't have the something else It is not easy to synthesize. We don't teach our students to synthesize. We don't know how to synthesize. Let me quote from Polyani. He says, "I have said that the analytic descent from higher levels to their subsidiaries is usually feasible to some degree while the integration of items of a lower level so as to predict their possible meaning in a higher context is beyond the range of our integrated powers." So we can't blame ourselves entirely for being reductionists if it is inherent in the way we think. It might be worthwhile to see why we think this way. But first, Let me conclude this first section by reading a summary. It is a kind of recapitulation. The situation we see in the Western world is facing a major crisis. This crisis is not attributable to any of our institutions in particular or even to the immorality of the institutions like the charge made that the scientists are now interested in power instead of truth, These are factors, of course. But the crisis results from our western ideas of the world. Our approach to epistemology, our theory of knowledge, and our methods for how we acquire knowledge have some errors in their very roots. So we see on one hand a reaction, a demand for being more practical, more relevant, more pragmatic. We want more immediate pay-off on our scientific research, and this is not unexpected, it is fair; but it is time that scientists be reminded that they are something besides scientists — there are also human beings and they too have to live in the smog. They have special responsibilities because of their special training. On the other hand there is the attack by the new revolution which sees the deterioration in human life both private and public as attributable to the scientific mode of thought. This constitutes a very strong challenge — one with the highest priority that science can accept. If we cannot reexamine our own processes which have contributed to these absurdities, if we are incapable of this, we are going to be written off. Now this can be taken as a prologue to what we are going to try to do here in these seminars. It is the rationale for our attempting to see if we can make some progress in understanding how we think, why we think the way we do, and see if we can not possibly come up with alternative approaches. we want to try to develop new canons and new ways of treating the kinds of problems that we are facing.

~~is going to be an exercise in imagination. We are going to try to go back to the most primitive conditions we can imagine of man when he has just come down from the tree. and He is just starting to live on the ground and we want to imagine how he might have developed his thought processes. As I say, this is an imaginative exercise more to illustrate things than it is to say how~~ they happened. This has not anything to do with history. But first, In this section we want to explore why we were led to think in this reductionist mode. We assume that since the human being is a part of nature, he shares with Nature the drive to put things in order, to structure them. This is one of the attributes of man. We like to organize, to structure. We have an intuition that there exists something like this in nature, that there is order and relationship in all experience and all phenomena that we encounter in nature. This is an article of faith upon which science itself is built. Nature is not capricious; it is orderly, predictable. You can test it today, or tomorrow, and so on.

The history of human thought centers about the mainstream of a few processes that men have designed so they can place order or organize their experience. It does not matter whether the experience is common experience, sense data, or data from sophisticated instruments, or whether it is just a mass of folklore which may be organized into myths or legends. What we hope we can do is design a structure for our experience of all sorts which is or isomorphic (that is, one to one) map of the structure that seems to be manifest in nature. This is, in one sense, what knowledge is all about. Can we create in our minds and with our symbols, a structure which is isomorphic to the structure in nature, although that structure may be cast in different mediums, it may be atoms, stars, or whatever, and the structure we are dealing with is symbols, propositions, plus signs, integral signs, and so on.

We know that the structure that we can impose on our sense data and experience is not unique. We are able to make alternatives. We are not even sure that the structure in nature is unique, whether it is monistic. This is an article of faith that many scientists have, that it is possible to reduce, and this is an important part of reductionism, the whole picture to one axiomatic system and then you could fill in a few boundary conditions and explain everything. I guess LaPlace is the last person who expressed that in such pure form.

Experience shows us that it is possible for us to make our constructs in alternate ways. So, as far as we know, there is no unique structure, but there may be an optimum structure. By optimum, we here mean one that is most useful for whatever purpose. The history of mathematics, you know for example, we can synthesize a great many structures but only a subset of these may have any relevance or isomorphism to the natural order. In fact, this is the new way of doing science. This is tracable to Hilbert and Whitehead. What you do is construct a system or a set of systems, an ensemble of systems, and then you search among those for the one that fits the natural world. The old way is to interrogate the natural world and experiment, and so on. But now you produce the whole ensemble of possible systems, and then see which one matches. That is predicated on what we know quite a bit of already. It doesn't predict quasars and pulsars and things like that. It depends on a critical mass that we don't have.

Epistemology involves many stages that we want to talk about; perception, conception, linguistics, rules for recognizing or blanking out experiences (and believe me, we blank out as many as we recognize). Then there are rules for organizing experience, tests for the validity of certain experiences on patterns. Epistemology involves creating frameworks for representation. It involves modes and abstractions. It involves what is it all about? What are we trying to do in the first place? Maybe we are doing to do this monistic thing of getting a few basic principles from which we can derive everything else. Maybe we trying something comprehensive to include everything, or maybe we are just trying to get something that is self-consistent. It will only cover a small set. Epistemology in the broad sense involves all these things.

Epistemology contains prejudices, hang-ups, and blind spots and you can look at some of these. Some you can trace to the sense organs themselves which are filters of experience.

Some we can trace to our though patterns. We may say some are the hardware — sense perceptions — and some are the software — perceptions which are culturally or parentally inculcated in us. We get some of our hang-ups from our culture.

Each of these stages may contain errors and fallacies and one of the jobs in the next few weeks is to go through these stages and see if we can detect certain fallacies. We might take one example of sense perception — we'll take a frog. There is a rule or law that seems to govern sensory response. It is that, we and animals are not aware of levels of absolutes; we are only aware of changes. This is the Weber/Fechner law, which states that it is change in the stimulus that determines the sensory response. Now you can put a frog in water and if you gradually heat the water, very gradually, the gradient of temperature with respect to time is very small, the frog is not aware that the temperature is changing and you can boil him to death. If you change the temperature very suddenly,he is going to hop out, he is aware of that to the strongest degree. Of if you change the temperature very very slowly over generations and generations, you can probably develop a species of frog that could live in a geyser. I don't know -- there are some chemical laws that come in too.

There is a kind of a three fold picture here. If this is a time axis, and this is a temperature axis -- if we make a sudden change here, the frog is going to jump out. If we make a very very gradual change here, down in here evolution might enter in and the frog could develop some way of surviving, but in this region he is going to boil to death. This is the nature of our sense filters. If we are faced with the smog gradually increasing little by little, we are going to suffocate. If it all came about in one week, we would all get up in protest and do something about it. This is the way we are and it is well to know that we are this way because we can be manipulated.

Let's imagine this primitive man sitting under the tree, two or three of them there, and they are squabbling over some piles of nuts and berries they have in front of them. They are focusing on entities; these entities could be stones or berries or nuts. These are the things they can get their hands on, the things they can see. They have a facility, a very important facility, they can tell when two things are different and they can tell when they are alike. This is the basis of all our cognition. This is the thing -- we have our senses, eyes, ears, and so on — but this is a cognitive aspect of the human being up here in the inside that determines to a very great deal our whole approach to knowing. We are able to behold the same and the not same. Now this leads to some operations. We can make piles or groups. One of the fundamental operations that we perform is grouping. Grouping means both combining and separating. Combining has its derivative operations, if you follow the sophistication as we go on down, you get to plus, times, exponentiation, and integration. These are all derivative from the combining operation. The separation operation gets more sophisticated in the division, subtraction, and so on. So these operations that we have abstracted come directly from the grouping operation that we performed and on its most base level, the operation is grouping, and grouping is possible because of this property of being able to behold the different and the same.

The next operation we can perform because of this facility is the ordering operation — one coconut is bigger than another coconut. The ordering operation leads us to the ordinal numbers and counting. Now the feedback from counting leads us to the cardinal numbers and we can see how many are in the pile.

The third thing that this ability to behold or differentiate same and different makes us focus on is entity — nuts, berries, stones — but not on relationships. The primitive man does not see relationships, he sees entities. He counts these entities. The fact that the berries have stems on them, which means that they are related to something, the carrots have roots on them that means they are related to something; this is of no interest or consequence, the thing is the piles in front of him. The relationships are de-emphasized. What he does is learn to break the nuts apart, and look at them carefully in their smaller parts. This leads naturally to analysis and in a more sophisticated sense, this is where our reductionism comes from. It is because the way we see and use our hands, we make piles and count, we group and order. ¶ Look at the dolphin. How does the dolphin experience the world? He can't make piles so he has probably evolved something else. He's got a sonar — he measures distances, he notices changes, changing rates — he probably is very aware of relationships, higher derivatives, second and third derivatives, etc. He has a different picture of the world. He's got a picture of the world which is probably a lot more complex and sophisticated than this ape that sits under the trees and derives everything from his ability to make piles and discriminate a nut from a berry. So we aren't surprised perhaps that the dolphin has a lot greater capacity in his brain than we do. I don't want to give this too much time since it is a myth, and make some other statements about it.

One day when this fellow sees two pieces of broken stone that fit together, he has done something new. He has synthesized. He has seen relationship, but relationship of a very special sort. It is a relationship where things touch each other and has a visible interface. Another thing that comes out of his earlier experience is the concept of consistency. He learns that the choice coconut cannot be in your pile and my pile both. It can only be in one pile at any one time. More subtly, later you learn that two things cannot occupy the same place at the same time. This is a possible antecedent for this idea we insist that everything be consistent, yet in our dream world we find that this is violated all the time. Certainly if we are dealing with physical entities, we have these two rules; an object cannot be in two piles at the same time, nor can two occupy the same space at the same time. That is before you discover quantum mechanics, of course.

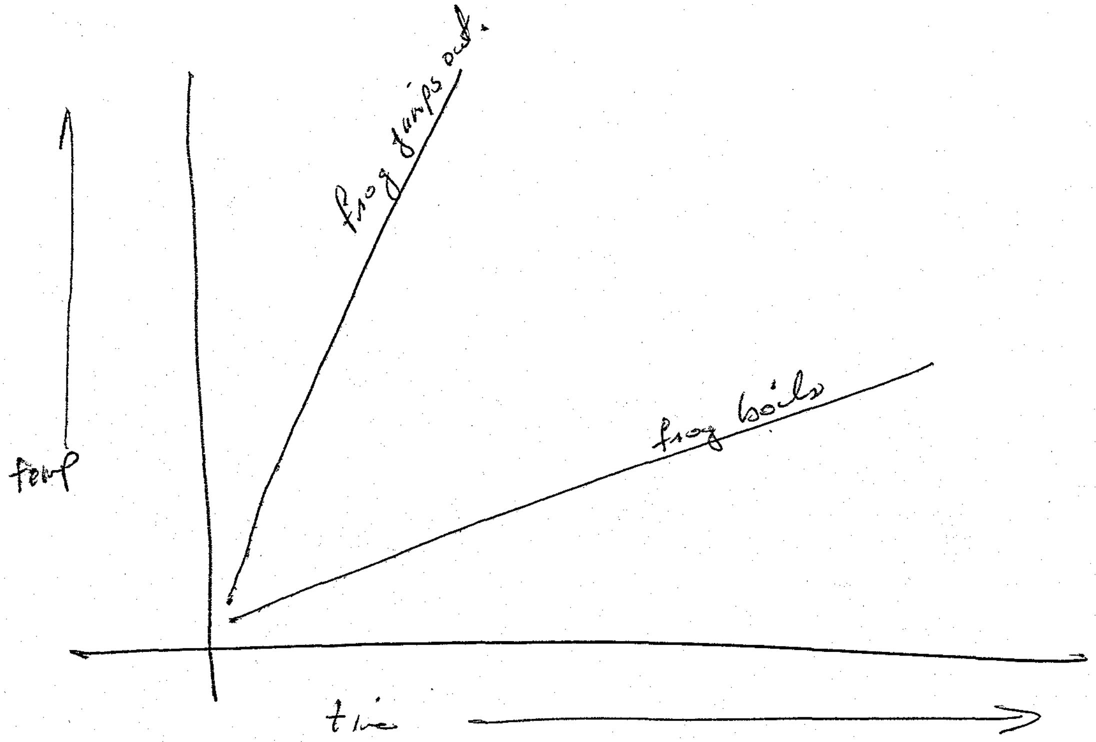
We go on and we get into the concept of correlation. A pile of stones is hot and a pile of nuts is cool. We are led to if I pick up a stone I get burned, if I pick up a nut, it doesn't bother me. We are led to if then, and this is an abstraction that comes and which is the basis later of the Aristotlian syllogisms. The point in this myth at this stage is the possibility that the deductive system is empirical and it came out of this particular type of experience. Abstraction comes when you see a commonality or similarity running through the whole thing. Everything is hot or everything is round or whatever, and so you get an idea of abstraction. One of these abstractions is number, like four. We find we make a pile of four apples, four nuts, four oranges, etc. There is something common to all those and after several thousand years you find that the thing that is common to them is four. This leads to learning how to abstract. ¶ We mentioned relationship, the broken stone. But there is another relationship and this is the relationship of lightning and the thunder and the wind and the tree bending. There is no connection that is visible and this is disturbing. It is terrifying and so we stay away from this. We can play with these piles and feel quite at home but when that wind is blowing and a tree breaks, we don't understand that at all. We begin to call this supernatural. It is an area we can't make our own. The idea of supernatural, the gods or forces, came about because our experience with piles did not lead us to understand anything about relations. And here are relations, and here is the beginning of action at a distance. If you want to name one of the hang-ups that is still with us, it is action at a distance. Beginning with Newton on for the last 300 years, a hang-up of Western science is action at a distance. We can't stand it. We have to have fields and we invent all kinds of gimmicks to account for this because it bothers us. It bothers us because it is not simple like the relationship between two pieces of stone that we can put together. This perhaps may explain why we prefer reductionism to worrying about relations. Now it is sometimes said that men focus on entities and women are able to see the relations far better than men. In the spirit of the myth, this is because the men were down on the ground squabbling over the piles and the women were back looking at the men and they saw something going on between the men, you see. This was the beginning of human relations.

There is a second thing primitive man began to do. He began to pick up sticks and draw in the sand. He made patterns. He began to see a second talent he had in addition to the ability to tell like and unlike. He began to notice regularities and certain things appealed to him. He could recognize patterns and in addition to the counting which came out of the pile making, we get geometry which came out of the drawings in the sand. Now If he had been drawing on apples instead of sand, we would change human history by several centuries. It has only been the last 150 years that we have learned how to draw on apples and get the proper geometry but we have this hang-up because we drew on sand and not on apples. The non-Euclidian geometr~~y~~ies only came about when Lobachevsky and Gauss began looking at curved surfaces. But back to drawing in the sand, there was also ordering, certain lines were longer than others, just like certain coconuts were bigger than others. Here were two things, a line that is longer than another line, and a coconut that is bigger than another coconut, and he would think about that,that there is something common about this. Then after thousands of years you come up with a tremendous abstraction, you invent this thing: = and this thing: >, but it comes from being able to see these arising in many contexts and many mediums that influence work, and one is the medium of coconuts and one is the medium of lines on the sand.

These two areas were merged, not early in the game, but only recently by Descartes. He showed one possible way in which man is a maker of piles and one possible way in which man is a sketcher of lines in the sand could merge these two historic trends. But let's be very aware that there may be other and better ways of doing it. His analytic geometry was only one possible way of doing this. I think we all seem to feel more at home with piles than we do with drawing in the sand. Most people prefer to operate with arithmetic and algebra than they do with geometry; I only know a handful of people who are more at home with the sand drawings than they are with the piles, one of them is sitting in this room. But I know a very famous geometer who is a really pile maker, although he calls himself a geometer. He works with symbols. The preference for piles, perhaps this is kind of unfair but I should say it anyway, over sand is last expressed in the fact that the digital computer won out over the analog computer. But we still have this in our language. You hear, "I want to talk about something I can get my hands on, get my teeth into." He is undoubtedly talking about the coconuts, and this drawing in the sand bothers him because that is talking about relationships and things are just a little too abstract for him to feel comfortable. So when you are talking to that guy you had better translate it into making piles.

The third thing that happened was a great economy when this abstraction technique was carried a little further. We make pictures, simplified pictures, and we discovered mapping symbols, and the derivatives of these things which go on down to concepts of isomorphism, homomorphism, etc. The third big step was this idea of mapping. How do we merge these three things. What are the various ways, can we think of alternative ways in which we can bring together our piles, our sand drawings, and our maps. What are the hang-ups that we inherit from the fact that we started out in this particular way. We might learn a lot about this if we could learn what the hang-ups of the dolphin are who didn't start this way. Well, we could name one of these hang-ups, one of them is our reductionism, our ideas of space and time being contiguous. We have gotten out of our Euclidian hang-up. We have our dislike of action at a distance and from our habit of focusing on the piles,we tend to ignore relationships and contexts. These are just some of the prejudices or preferences that have come to us through evolution of this sort. Since it is a myth, it should not be taken dogmatically. It's just an illustration of how things that we do are in some way related to the way we look at the world today.

Figures for frog on p. 15 — 23 JAN 1969



QUESTIONS/AMPLIFICATION: Seminar I: Frontiers of Epistemology

(171) M.Bendick: Is it really science and the modern world, an increasing dehuminazation thats generating this flower-power rebellion? I wonder for example, if the Midaeval Serf's life was any more or less dehumanized. I would put forward as a spark for discussion, that he was just as dehumanized. That dehumanization or rather the level of dehumanization is not really attached to the level of technology in the society at all and that the only reason you have people today speaking about dehumanization and trying to change society is because there's a much freeer society. People have the leizure to address these kinds of considerations and to throw in a little bit of McLuhan for spice, you have more publicity so people know other people are thinking the same things and suddenly it becomes a movement.

(179) A.Wilson: I certainly agree with your last statement that this gets a certain amount of momentum because of communication. But the question is dehumanization linked with the level of technology is, I think, a question of necessity and sufficiency. There are a great many ways to be dehumanized -- there were a great many ways the human race was dehumanizaed long before we had technology, but there are two questions in my mind. One is the relation of technology to dehumanization -- is there something implicit in technology that leads us to dehumanization and the other is the question of gradient rather than level. I couldn't answer your question of whether the serf was more dehumanized than a man today, but I think our concern must be with the vector. If the slope is down towards more dehumanization, this should alarm us and

we should not wait until the condition is impossible -- when we realize our condition is no better than the serfs were in the twelth century.

(181) M.Bendick: The point I was getting at was perhaps the level of dehumanization is completely irrelevant to technology or vis versa. The level of technology is irrelevant to dehumanization. Dehumanization is perhaps a function of the ability of people to communicate with one another. It doesn't matter if they're sitting in a serf's cottage in the Middle Ages or sitting here in an ultra-modern room in a space center in Southern California. It doesn't matter what the lighting is or what the chairs are, the question is can the two people communicate?

(192) A.Wilson: Are you raising the question that the level of communication is associated with dehumanization?

M.Bendick: Well, I'm throwing that out just as an example perhaps. The level of communication or something purely social and psychological is functionally related to dehumanization.

(193) A.Wilson: Of course you could say the level of communication is derivative from the level of technology too, so --

(194) B.Williams: We're getting into a couple of hang-ups here. One, I think is that we think in terms of absolutes. The other is that you can separate lack of communication and things in technology. This leads into problems of reductionism again. I don't think it has to do with the level of technology but it has to do with a lack of concern with our own relation to technology. If technology means

we can build bigger bridges or a more efficient freeway, there's a corresponding lack of questioning how do people feel when they get on that freeway, even though it does work very efficiently.

(201) J.Brimsley: I think we'd all agree we have an appearance of dehumanization and I'd like to exam the existence of that.xxxxxxx. Lets go back to this vector -- progress is a vector and it's measured in some dimensions. Some of those dimensions are technical, but the question we should exam is whether the vector in the humanistic or soft sciences is going negatively or the case really is that our methods are good, but we put too many of our eggs in a technical basket. Possibly because its easier to do things technically. So, I question the conclusion that methods are at fault or rather, we have to establish first, what the situation is. Are we really, or do we have a positive vector in the humanistic and social areas? If that vector is negative, them our methods are at fault.

(209) A.Wilson: Well, our methods may not necessarily be at fault. Your first question, Is life better today than it was twenty years ago. There's been a survey made, asking people if they are happier and the answer is no. Are you less happy? -- yes. And as you say, it may be an appearance.

J. Brimsley: Yes, I think that's the nitty-gritty of all this. That question has got to be resolved. One explanation of all this unhappiness may be that they know more of what's going on and have a better selection of complaints.

(214) M. Stein: I think it's due to expectations. I think it has to do with communications obviously and with technology I think our expectations and definitions of happiness are a hellavu lot higher than they use to be, than twenty years ago or especially back to the Serf's type of life. I think as technology grows your expectations grow and I think the major problem is now as it was then, that you must be able to at least think you can reach the level of those expectations.

(218) A.Wilson: Well, this is an extremely important factor, because as you know scientists have gone out trying to sell science in obtaining funds and so on. They have themselves created high expectations. If you fund us, tomorrow the world is going to be one blissful garden.

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A. Wilson: Well, I don't have to argue about whther or not smog is good or that I don't like holding over Kennedy Airport for hours. I don't need a study to convince me that I don't like these things. And I'm sure that the people in Vietnam who are getting napalmed don't need a study to find out they don't like it. Some of these things are rather straightforward. It isn't....You raise the question of appearances, and I wonder if we haven't all watbhed so much TV that we lost the ability to tell the difference beteeen reality and appearance. We can't really get a feeling for what's happening....it may must be happening on TV, so one of the things we'd better do is to figure our how to tell the difference between these two worlds again.

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in a country. Theres a relations between the liklihood of violence and the level of development in the country. It turns out that this is a concave function. The less developed countries have a low liklihood of violence. The highly developed countries also have a low lilihood of violence, but the ones in the middle -- the ones that can see the rich, fat, happy guys and know what they're unhappy about and have the ability to do something about it -- they have violence.

D.Wilson: Yes, I could also confirm that in the rioting studies. Those who rioted were not those who were really down and out, but rather they were the ones who had higher educations and hence higher expectations.

(232) J.Brown: That basically gives you a measure of humanism then. In other words, the amount of violence per capita is a measure of humanism.....

A.Wilson: Well, do we want to settle for a one parameter measure? It could certainly be one ingredient.

J.Brimsley: Is humanism just complacency? If we are complacent, then do you conclude that the population is humanistic.

R.Williams: We're very humanistic in that case.

A.Wilson: Well, youre touching on something thats very basic that we haven't mentioned so far. That is the value system. Maybe we like an environment that irritates the hell out of us because this makes us more something or other...

(236) J. Brimsley: Well obviously, this environment is more humanistic to you than any other because you're here. I mean, when you put everything

together, you're here and not some place else.

A.Wilson: I'm not going to buy that, because that's predicated on total freedom of choice. It's like the bumper sticker, Love It or Leave It. I love it, and I criticize it, but I'm not going to leave it.

Brimsley: Why is that? Maybe that can get us to what humanism is.

A.Wilson: Well, I think its a sense of commitment that we do take a challenge. Maybe this isn't the worst of all possible worlds, but in view of expectations, we can conceive of a better one. If you don't like the way this one is going and you don't have to live in Watts, you can not like a lot of things about it. And we make a commitment to head off its getting worse. I think this is a quite human and rational response. For exmple, you look at the chart of the average holding times over airports you can see that its going up. Forty minutes year before last, it was about fifty four last year and who knows what it will this year and so on. I feel we should respond to these things.

J. Ouye: Is that really the reason people say that the level of happiness is going down? That people are held up forty minutes in the air? I think those things are sort of side things. Isn't the main thing alienation? There's an author named Giddeon who wrote something on machines -- Techniques and Civilization, I think -- and he threw out the idea that one way of thinking of technology is that its specialization. And his point was that, sure we've reduced our environment and in the process, we've reduced our own lives.

We've become specialized, just like parts of a machine... the machine of society and that's why we're alienated. We don't interact with the many faceted parts of life.

A.Wilson: Well yes, an alienated man is an unhappy man.

(253) J. Ouye: Yes, take the Surf for instance. You say that he might have been as unhappy as we are, but if you take it from the view point of alienation, he made his own food, he made his own home, his own clothes and so on. Everything to do with his own life, he probaly had a hand in it, creating things, destroying things, and so on. How about us? When we want food, we go to a grocery and buy it. We really don't have any part in the process of making it. When we want to bury our relative, we don't bury him, we tell the funeral director to do it and so on and on.

M.Bendick: People usually do cite this type of specialization, but I don't know. I've gone into a grocery store many times and I've never felt upset that I didn't grow the stuff. It seems to me a totally academic argument.

(258) J. Brimsley: I don't see how your any less a part of it if you hand a guy a dollar bill than if you grab hold of a shovel, or a piece of wood on the end of a shovel and move a hunk of dirt. Youre doing it indirectly in both cases. Youre no less a part of the process in the grocery store.

B.Miles: I think its the amount of time you spend in taking care of your needs. We don't have to spend as much time these days, taking, care, or rather interacting with the environment in order to take care

of our basic needs as the Surf did ar even as much time as the 1940 factory worker did.

A.Wilson: But we're spending more time in ques and at red lights and things like that. You might even say that it takes less of our time to produce food than it takes to tear it out of the package.

B. Miles: No, I really don't think so. You might say you have more time now to do other things that what it takes to make a living.

Voices: Your'e getting to New York faster.

B. Miles: The freeway holds you up, but in the long run, you get across town faster.

A.Wilson: I think you're getting the answer -- its a tradeoff. We're willing to put up with a lot of smog and a lot of other noises, we're willing to put up with the Damoclese sword of super-weapons for getting to New York faster. But I'm raising the question, do we have to accept this kind of tradeoff?

B. Parkyn: Well, we didn't really ask for it, its just there.... I

wanted to ask something else about this reductionism. It seems to me that its more than just these explicit canons. I think they were expressing something that was much deeper. For example, life-style of people. How would life style express this type of reductionism? In other words, how do people relate to their neighbors, their kids, their possessions? Nowadays, people look on their possessions primarily as an investment in economic value or else as something they consume and throw away when its done with. People have no real relation to the material. In other words, they wouldn't love this table because

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(276) A.Wilson: I like your point about alienation and waste. I'm rephrasing it slightly, but we don't really get attached to anything. We're quite willing to throw away. We don't form a relationship with The old table, the old shoe, the old neighbor, or anything. We don't have any permanent feeling about anything. This is partly due to the mobility in our society. If a situation gets a little tight, we just get up and move. So this question of alienation which really means the breakdown of relationships is a first cousin to reductionism which ignores relationships.

(281) G.Bocher: I wanted to comment that I think one aspect of the changing scene -- and I think it is chaning, I agree with Al, that the porportion of human -- person to person contact is decreasing. Relationships are not deep. A person may know dozens and dozens of people, but he may know noone well. In other societies this situation

is somewhat different. In some societies, the circle of friends may be very small but the relationships are much more deep and meaningful than what the average American experiences. I think our increasing mechanization applies here. We interact less and less with people and more and more with systems and machines. I don't know whether people care about this or not, but many are not even aware of it.

J.Brown: This is another measure of humanism, the degree of how much we interact.

A.Wilson: This certainly lowers the quality of life for many people.

B. Miles: But there is a search though, I think more than before there is a quest for this kind of interaction. You see it in the T Groups, the Easelen thing. I think these are really a search for meaningful relationships. These were things you never heard about in the forties and fifties.

Voice: But isn't that kind of thing, phoney?

B. Miles: No, I don't think so in the least.

A. Wilson: Well, here we're getting outside the subject. We'd better leave T Groups to another time. and I'd like to go to part two:
(293) which will be an exercies in imagination. We're going to go back
to the most primitive condition we can imagene of man who has just come down from the tree and begins to live on the ground.

QUESTIONS/AMPLIFICATION II: Seminar I: Frontiers of Epistemology

(324) **J. Stromberg**: I would like to ask a questions for clearification. Am I correct in understanding you when you talk about nature and the natural order and the structure it has, that youre stating that you believe there exists an independent structure, nature, whatever,... something that exists independently of you or me. That is it is ~~xxx~~ something other than our perception of it or our interactions with it?

A.Wilson: Yes, this does need clearification, although this question has been debated for centuries whether we take the position of Hume, Locke or Berkeley. Whether we are talking about the structure existing here or out there . Is there some sort of dualism and so on. The point I want to make is not really dependent on how you resolve this mind-matter problem, but rather a parallel structure between a set of operations we do on the Natural Order, whatever the natural order is....things we do with our hands, testtubes and so on and how we set up a set of symbols to map those. I will want to get into this question of the implications of our metaphysics for our epistemology, which is the question you raise, but I think for the moment, we can just say it has two aspects. One is the aspect of our symbols to represent it , The other is the aspect of our sense experience. What the ultimate nature of these are, we won't go into now. I don't want to go quite that deep for now. Will you settle for that? (338)

(360) **B. Miles**: On the matter of the frog boiling and concluding we are subject to manipulation, couldn't we also develop biological adaptation?

A.Wilson: Yes, and we could hope that our children would love smog.

(384) J. Stromberg: We can look at two things and decide whether they are different or the same. I believe, two things, by definition are always different. We choose to look at the world, whatever that means, in terms of same/different.

A. Wilson: You're exposing the punch lines. This is a very important point and I want to go into that in detail later. When you have just two things, when you have three, whether the universe is a Pauli universe where no two things are exactly alike and so on

(407) V. Gradecak: For clearification, aren't we assuming that the basic ability of mea , primitive man and modern man are the same? I seem to remebber observations reported by others that this is not a valid assumption. Primitive man and/a given man only two thousand years ago had different abilities in his inate sense perceptions than the modern man has. Consequently his thought processes, like that of a dolphin were different in primitive times than they are today. And sometime shouldn't we devote some time to that question?

A. Wilson: Let me comment as follows: theres no question that they're different, but when a stream starts down the side of a hill, what happens in the first few seconds, the path it cuts, that little rut later determines the course of the stream. And what happened originally has played a deterministic role in what we have become. Now, this isn't just surmise. We have some laboratory studies. In the past year, Donna has held several workshops in which we have investigated this very question. We give people data in the form of cards on which are printed items describing experience and we ask people to structure this data. One must start ab inition, just like the primitive man. Each is to put these together in some way that appeals to them personally. Everybody in the room does it differently. But the next time, if you take one of these sets as a pre-structure and give it to other people, they build on it and what they do is determined by what you give them in the first place. We are in some sense derivative from this guy sitting under the tree with his piles but it doesn't mean we are the same by any means. No more than the operation of integration is the same operation as scooping up some nuts in a pile. Theres a big difference, but one has evolved from the other.

(427) J. Stromberg: I think that youre telling us a myth about the primitive nature of the thought of people today. I think its a useful myth or metaphor, but

Voice: It was so stated in the beginning.

Stromberg: Well, ok, but I'm sorta attached to some other myths and metaphors ....

Wilson: Good, I hope you'll describe yours later. I don't want to give too much time, then since it is a myth but there are some other statements I want to make about it. One day...............

(516) J. Brown: I'd like to mention this thing you said about the frog. I think the only things we are ever aware of is the change in our life.

Wilson: Yes, thats the Weber/Fechner law.

Stromberg: Sounds like ancient Chinees philosophy to me. The I-Ching.

J. Brown: Do you have an alternate to that?

Stromberg: No, I was just saying that he calls it the Weber/Fechner law, I said it sunded like the I-Ching to me.

Williams: Possibly an alternative myth to go along with the one you've got is what Voya was mentioning. In primitive man's case, he had well developed senses and he had a very good sense of the environment and how he interacted with it. As he moved out of that, the contact with that environment dimished and today we've lost a great deal of that sensitivity about our feeling. We put out money for food instead.

Wilson: Yes, going back to Easelen, we find they are trying to recapture some of this.

Voya Gradecak: I would like to relate a few scenes from a movie I once saw. It was about some Australian aborigine who is considered to be the oldesnt known primitive persons who are non interacting with other races. Some of the scenes that were fliting through my mind as I was listening to what primitive man does or might have done when confornted with piles of rock were different. Let me tell you what I saw. He was using a stick, he was a very lean man, perhaps six feet tall, spindly, almost skeleton as a natural appearance. Tremendous bushy hair, a big head, and he was singing in a chanting way and he was rhythemically hitting the ground with this stick. He was performing a magical act. He was invoking gods. This was his first concern and it was all in connection with his young charge a boy, age thirteen who was to be initiated into manhood.

The way the cermony was performed it included a great amount of suffering on the part of the boy. To be taken with equnimity, because in the face of gods, you do not fail. If you do, you are through. Matters which are far more close to the primitive man -- dancing, divining, magical acts - reaching for the gods all the time. So they have learned how to survive in the Austealian desertalmost naked. They wear almost nothing, man and woman alike, but winds are fierce and nights are cold. They have no water, the land is arid, but they know how to survive, while white man with all the equipment perishes again and again. And so they are not concerned beyond this point of survival and infinite perception of what is divine. On close contact with Western civilization, they usually perish. So they are not left unto themselves. They are not civilizable. Something to think about.

<u>Wilson</u>: I think you have achieved the greatest bit of one-up-man ship by pointing out what we have been discussing here is/~~simply~~ really a very, very special case. The totality of things that humans can do and don't do in our culture anymore. Perhaps we should at some time in this series look into this direction. I'm very empathetic with what your saying, but I feel we have to go from the very concrete and reductionist culture we live in and try to open up in every way. The avenues your speaking of are some of the most important.

(565) <u>B.Miles</u>: Is it saying the same thing that we're looking at a strickly rational point of view -- we are looking at a development that had some other behavioral faculty?

J. Brimsley: Since we've practiced reductionism since,,,,we'll our recorded history is a result of reductionism,the myth I would suspect, or rather offers the question of whether or not the myth too isn't a product of the reductionism it describes. (Wilson: Yes, just as Voya so beautifully has shown) So, what was the real myth? Did a rock fall on his head or did he touch a flat slab and all of a sudden, he knew? It would be fascinating to see an alternative myth, hopefully a conflicting myth resulting from some other practice other than reductionism.

J. Gauger: Can we construct a myth that says, instead of Isee, I feel or I smell. The totality.

Voice: Lets not leave it with perception, how about I love, or I desire or I ,

Brimsley: It seems like its another construction. You base it on the same evidence on which we've based this one using the same procedures.

M. Stein: But the point is there are many modalities of being and experience, the rational is only one

J. Gauger: Is not what you term rational, a function of the sense we use the most , the eye? We don't use particularly, the touch, the smell, the hearing, The dolphin however, uses hearing and he developes a different way because of the sense he's using.

M.Stein: I'm wondering if theres a bases for knowledge other than the rational.

J. Brown: The aborigine is rational, because he survived.

M. Stein: Well, his god gave him knowledge. Doesn't God give us knowledge? They don't anymore.

J. Brown: It may be irrational to us, but it must be rational becase he survives.

Brimsley: I don't know whether he is rational or not. The point is we're both survivable.

J. Brown: Well, we may not in this environment.

A. Wilson: Well, there are many bases for knowledge. We can say that knowledge is a pattern that's a priori in us. We do not discover, we do not invent, we recollect. we remember. The sense experience triggers a memory and what goes on out there is suddenly mapped on something thats in us. Theories of that sort have been proposed. Thats irrational, but it has to do with knowing that is independent of sense data.

Stromberg: Thats not irrational....(Wilson: Yes thats right, its transcendental sense data)...well, its non-consenses at the moment in the intellectual establishment.

B. Parkyn: Theres an article in the latest Science New Letter that makes that point, that neurologists are starting to think that. That because of all these culture maps we have, you see something interesting and it turns one map on.

Wilson: Well, I think the spirit of what we do here has to be speculative. We are trying to free ourselves of a party line and we can't be dogmatic. I think any alternate ideas — far fetched or not — are grist for our mill.

(603) V. Gradecak: I would like to make just one suggestion. In addition to being speculative, if we could in a free spirit, investigate .... If we could contribute as we come across observations of very unusual observations of record. In order to base speculation on something that apparently is subject to observation, that does not fit or refuses to fit the ....of present knowledge. To mention a few examples: The recently published book: "The World of Ted Sirios" by Eisenbud.

Wilson: Let us make ~~xx~~ it a homework assignment to bring in these references, to make a file of all these phenomena which establishment epistemology falls on it face with.

Voya Gradecak: I would strongly recommed the paperback books of Charles Fort, 3 or 4 volumens, specifically"The Book of the Damned"

Wilson: Such a collection would be very useful because we can find the epistemological base to confront every one of these, we've failed.

J. Brown: Is anyone here aware of this guy who runs his hand over the stomach and an appendix comes out? I can look that up.

J. Gauger: This weeks, Time in the science section has a write up on ESP including the work at Boing.

V. Gradecak: Oh, yes, it comes to mind, a long physician, Walter Kilner published a book in the twenties called Human Aura. It describes his chemical experimentation involving perception of human ~~xxx~~ aura and he later did diagnostic work using these methods. Subsequently, Oscar Bagnell

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Epistemology

ok to cut/paste

QUESTIONS/AMPLIFICATION: Seminar I: Frontiers of Epistemology

(171) M.Bendick: Is it really science and the modern world, an increasing dehuminazation thats generating this flower-power rebellion? I wonder for example, if the Midaeval Serf's life was any more or less dehumanized. I would put forward as a spark for discussion, that he was just as dehumanized. That dehumanization or rather the level of dehumanization is not really attached to the level of technology in the society at all and that the only reason you have people today speaking about dehumanization and trying to change society is because there's a much freeer society. People have the leizure to address these kinds of considerations and to throw in a little bit of McLuhan for spice, you have more publicity so people know other people are thinking the same things and suddenly it becomes a movement.

(179) A.Wilson: I certainly agree with your last statement that this gets a certain amount of momentum because of communication. But the question is dehumanization linked with the level of technology is, I think, a question of necessity and sufficiency. There are a great many ways to be dehumanized -- there were a great many ways the human race was dehumanizaed long before we had technology, but there are two questions in my mind. One is the relation of technology to dehumanization -- is there something implicit in technology that leads us to dehumanization and the other is the question of gradient rather than level. I couldn't answer your question of whether the serf was more dehumanized than a man today, but I think our concern must be with the vector. If the slope is down towards more dehumanization, this should alarm us and

we should not wait until the condition is impossible -- when we realize our condition is no better than the serfs/ were in the twelth century.

(181) M.Bendick: The point I was getting at was perhaps the level of dehumanization is completely irrelevant to technology or vis versa. The level of technology is irrelevant to dehumanization. Dehumanization is perhaps a function of the ability of people to communicate with one another. It doesn't matter if they're sitting in a serf's cottage in the Middle Ages or sitting here in an ultra-modern room in a space center in Southern California. It doesn't matter what the lighting is or what the chairs are, the question is can the two people communicate?

(192) A.Wilson: Are you raising the question that the level of communication is associated with dehumanization?

M.Bendick: Well, I'm throwing that out just as an example perhaps. The level of communication or something purely social and psychological is functionally related to dehumanization.

A.Wilson: Of course you could say the level of communication is derivative from the level of technology too, so --

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in a country. Theres a relations between the liklihood of violence and the level of development in the country. It turns out that this is a concave function. The less developed countries have a low liklihood of violence. The highly developed countries also have a low lilihood of violence, but the ones in the middle -- the ones that can see the rich, fat, happy guys and know what they're unhappy about and have the ability to do something about it -- they have violence.

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A.Wilson: Well, do we want to settle for a one parameter measure? It could certainly be one ingredient.

J.Brimsley: Is humanism just complacency? If we are complacent, then do you conclude that the population is humanistic.

R.Williams: We're very humanistic in that case.

A.Wilson: Well, youre touching on something thats very basic that we haven't mentioned so far. That is the value system. Maybe we like an environment that irritates the hell out of us because this makes us more something or other...

(236) J. Brimsley: Well obviously, this environment is more humanistic to you than any other because you're here. I mean, when you put everything

together, you're here and not some place else.

A.Wilson: I'm not going to buy that, because that's predicated on total freedom of choice. It's like the bumper sticker, Love It or Leave It. I love it, and I criticize it, but I'm not going to leave it.

Brimsley: Why is that? Maybe that can get us to what humanism is.

A.Wilson: Well, I think its a sense of commitment that we do take a challenge. Maybe this isn't the worst of all possible worlds, but in view of expectations, we can conceive of a better one. If you don't like the way this one is going and you don't have to live in Watts, you can not like a lot of things about it. And we make a commitment to head off its getting worse. I think this is a quite human and rational response. For exmple, you look at the chart of the average holding times over airports you can see that its going up. Forty minutes year before last, it was about fifty four last year and who knows what it will this year and so on. I feel we should respond to these things.

J. Ouye: Is that really the reason people say that the level of happiness is going down? That people are held up forty minutes in the air? I think those things are sort of side things. Isn't the main thing alienation? There's an author named Giddeon who wrote something on machines -- Techniques and Civilization, I think -- and he threw out the idea that one way of thinking of technology is that its specialization. And his point was that, sure we've reduced our environment and in the process, we've reduced our own lives.

We've become specialized, just like parts of a machine... the machine of society and that's why we're alienated. We don't interact with the many faceted parts of life.

A.Wilson: Well yes, an alienated man is an unhappy man.

(253) J. Duve: Yes, take the Surf for instance. You say that he might have been as unhappy as we are, but if you take it from the view point of alienation, he made his own food, he made his own home, his own clothes and so on. Everything to do with his own life, he probaly had a hand in it, creating things, destroying things, and so on. How about us? When we want food, we go to a grocery and buy it. We really don't have any part in the process of making it. When we want to bury our relative, we don't bury him, we tell the funeral director to do it and so on and on.

M.Bendick: People usually do cite this type of specialization, but I don't know. I've gone into a grocery store many times and I've never felt upset that I didn't grow the stuff. It seems to me a totally academic argument.

(258) J. Brimsley: I don't see how your any less a part of it if you hand a guy a dollar bill than if you grab hold of a shovel, or a piece of wood on the end of a shovel and move a hunk of dirt. Youre doing it indirectly in both cases. Youre no less a part of the process in the grocery store.

B.Miles: I think its the amount of time you spend in taking care of your needs. We don't have to spend as much time these days, taking, care, or rather interacting with the environment in order to take care

of our basic needs as the Surf did ar even as much time as the 1940 factory worker did.

A.Wilson: But we're spending more time in ques and at red lights and things like that. You might even say that it takes less of our time to produce food than it takes to tear it out of the package.

B. Miles: No, I really don't think so. You might say you have more time now to do other things that what it takes to make a living.

Voices: Your'e getting to New York faster.

B. Miles: The freeway holds you up, but in the long run, you get across town faster.

A.Wilson: I think you're getting the answer -- its a tradeoff. We're willing to put up with a lot of smog and a lot of other noises, we're willing to put up with the Damoclese sword of super-weapons for getting to New York faster. But I'm raising the question, do we have to accept this kind of tradeoff?

B. Parkyn: Well, we didn't really ask for it, its just there.... I wanted to ask something else about this reductionism. It seems to me that its more than just these explicit canons. I think they were expressing something that was much deeper. For example, life-style of people. How would life style express this type of reductionism? In other words, how do people relate to their neighbors, their kids, their possessions? Nowadays, people look on their possessions primarily as an investment in economic value or else as something they consume and throw away when its done with. People have no real relation to the material. In other words, they wouldn't love this table because its got nice looking wood. Its just something to use and when it gets scratchy or the corners get rounded, then out it goes. And this is very opposite to materialism. This is where money has become the God-motive. Money is the center of the Universe. and thats how our whole attitude gets structered through this abstract thing. You take a primitive man who supposedly is less knowledgeable than us, He's going to look at a man who goes into a factory or a desk and sits down and pushes a pencil for eight hours and hates it, but he gets these green pieces of paper and goes home and handles these pieces of paper and all through this long process, the primitive man would swear we were insane. I wonder how advanced we really are.

(276) A.Wilson: I like your point about alienation and waste. I'm rephrasing it slightly, but we don't really get attached to anything. We're quite willing to throw away. We don't form a relationship with The old table, the old shoe, the old neighbor, or anything. We don't have any permanent feeling about anything. This is partly due to the mobility in our society. If a situation gets a little tight, we just get up and move. So this question of alienation which really means the breakdown of relationships is a first cousin to reductionism which ignores relationships.

(281) G.Kocher: I wanted to comment that I think one aspect of the changing scene -- and I think it is chaning, I agree with Al, that the porportion of human -- person to person contact is decreasing. Relationships are not deep. A person may know dozens and dozens of people, but he may know noone well. In other societies this situation

is somewhat different. In some societies, the circle of friends may be very small but the relationships are much more deep and meaningful than what the average American experiences. I think our increasing mechanization applies here. We interact less and less with people and more and more with systems and machines. I don't know whether people care about this or not, but many are not even aware of it.

J.Brown: This is another measure of humanism, the degree of how much we interact.

A.Wilson: This certainly lowers the quality of life for many people.

B. Miles: But there is a search though, I think more than before there is a quest for this kind of interaction. You see it in the T Groups, the Easelen thing. I think these are really a search for meaningful relationships. These were things you never heard about in the forties and fifties.

Voice: But isn't that kind of thing, phoney?

B. Miles: No, I don't think so in the least.

A. Wilson: Well, here we're getting outside the subject. We'd better leave T Groups to another time. and I'd like to go to part two: (293) which will be an exercies in imagination. We're going to go back to the most primitive condition we can imagene of man who has just come down from the tree and begins to live on the ground.

II: Limitations of Science

30 January 1969

We start today with some of the limitations in our scientific method. We hear a lot about the power of the scientific method and we have all around us monuments to its successes. We tend to ignore its limitations. I am not trying to be negative when we stress here its limitations. It is through a critique of the limitations of the scientific method that we probably are going to be able to make some advances in strengthening it. We raise the question whether we are going to use the term "scientific method." What we are really talking about is something more general than the scientific method. It is the total epistemological tool kit that is available to us — how we accumulate knowledge, how we organize experience, how we structure experience and communicate the results.

Throughout history we have always been confronted with phenomena we cannot explain. This is nothing new, but with the growth of this organized body of knowledge we call scientific knowledge, we find that the time between encountering an unknown or new phenomenon and the time when we can start to explain it is getting shorter and shorter. We are having less difficulty explaining new phenomenon. We do not have to resort to wild hypotheses or introduce radical new constructs, so we become rather confident that we are on the right track. We have a set of theories that cover a great many new experiences, but more important, we can predict. We predict many new phenomena. But on the other hand it is also becoming apparent that there are certain sectors of our experience that are not yielding to explanation through the traditional scientific approaches. You can say well, this is okay, we just don't know enough yet and if we wait awhile, science is going to make adequate progress and pretty soon we'll be able to take care of any puzzles that remain with known laws and relationships.

We have in astronomy one such puzzle that has been on the books for quite a while — the Titius-Bode's law. There is no explanation for this pattern and for over a hundred years nothing has come up to explain it. There have been some tangential explanations of it but without introducing some new factor, a new law or principle or relation, we have not been able to clear it up. It isn't just a matter of postponing an explanation as in Bode's law. Some phenomena or patterns are not being postponed for the future, they are actually denied. The phenomena of ESP, for example, have been denied by certain quarters for many decades; their claim is that there is no such phenomena, it has not been established that there is such phenomena so, why worry about it. Frequently instead of collecting data or trying to formulate hypotheses, we find objective scientists begin to ridicule these phenomena. You can look at the Condon Report for documentation of this type of thing. Another recent example is the meeting of the National Academy of Sciences at the California Institute of Technology last month in which Jeffrey Burbidge presented data on clustering of redshifts. He showed evidence that redshifts do not seem to be randomly distributed but occur in a discrete value. The reception to this presentation was not to raise questions or to criticize, it was to giggle. This is a phenomenon in itself and it needs some further examination.

Perhaps one reason that we find certain sectors of experience not being studied is that scientists, like most people in this culture, are success-oriented so they attack the problems in which there is a promise of getting a solution. In fact the definition of a good scientist is a man who knows what problems to work on. What is meant by 'good' problems to work on, is those problems that can most likely be solved. It does not mean the problems of greatest import or significance or problems that need solution, but rather, problems that can be solved. It may be that these giggles that are encountered at meetings where UFO's are mentioned are some sort of psychological reaction to a feeling of being threatened. I cannot go any further with this, except to say that to me, it is a very curious phenomena. It may be that scientists are conscious at some subliminal level that there is a defect in our approach.

Let us be more specific. Let us look in more detail at what some of the limitations and prejudices of our current scientific way of looking at the world are. I will use three kinds of classes; a limitation may be intrinsic, it may be habitual or it may stem from emotion. If it is intrinsic, it means a necessary limitation.

If it is habitual, it just means that it is a habit, a way of doing things. It is not necessary to do it that way, it is just a habit that we have fallen into. Then there is the limitation that contains an emotional component which we call prejudice. Let's look at some of these. Some of these limitations can be called conceptual limitations, later we will mention some that are perceptual limitations. Conceptual has to do with our thinking rather than our senses.

The last time we mentioned the first and most important limitation, and that was reductionism. Reductionism is a limitation in our thinking that is a habit of thought; it is not essential or intrinsic. Reductionism is a habit of ignoring the context in which the problem is imbedded. We see the entity but we don't see its relation to its surroundings. We can design a beautiful car but we don't take into account looking out the windows in order to see where the other cars on the freeway are. We have many blind spots. Most design that is reductionist is subject to defects of this sort. Here, the entity itself is considered in the design, it determines the design prescription but reductionist design does not consider the parameters affecting the relation of this entity to its environment. We discussed reductionism at length last time.

A second conceptual limitation is the problem of contiguity. The way it is usually phrased is the problem of action at a distance. Action at a distance has been a stumbling block for years and it still is a stumbling block. I would call it an intrinsic limitation, the way we look at the world. I think it goes back to the fable of primitive man making piles of berries and sand drawings whenever there was a relation or action between two things there must be a physically visible connection. It is getting this one thing out of our head –– that there doesn't have to be connections between entities that are perceptible to us, that we don't have to reduce everything to some kind of Rube Goldberg lever pulley connection –– that will allow us a lot more freedom in building constructs. A previous invention to get around the dilemma of action at a distance was the invention of the field. This construct has been with us so long and we are all so much at home with it that we don't realize that the idea of the field –– gravitational field, magnetic field and so on –– was considered an outrage at the time it was proposed. People rebelled at the idea of a field providing certain properties without having a real connection visible. But action at a distance still troubles us from time to time.

Now there are some other limitations. One is hypothesis feedback on the validity of phenomena. By this I mean when we are trying to establish whether a certain phenomenon is real or not and a hypothesis to explain it exists, we get mixed up on our view of the hypothesis and the validity of the phenomenon. This hypothesis contamination of not keeping distinct the operations that we have to go through to validate hypothesis is a limitation. The first operation we have to go through is to determine whether the phenomenon is real or not, whether it is valid. Then we must formulate a hypothesis, and test the hypothesis. If we kept these operations straight, we wouldn't fall into these millions of prejudices and emotions.

For example, consider the canals on Mars. Percevile Lowell set up his observatory to study these markings that Schiaparelli found. Lowell observed these linear markings, he made maps and other observers also made maps that looked like Lowell's maps. Trumper was another very good observer. Some observers however never saw the canals; some very fine observers, Bernard, for example, could never see the canals on Mars. But the criticism wasn't on whether or not these linear markings exist, rather it centered on what Lowell proposed as an explanation of the canals. Lowell felt the canals to be constructed by some intelligence on the planet Mars. If you read the literature, the attack on whether or not the canals existed was not on establishing the phenomenon, it was on Lowell's hypothesis of their origin. These two things were mixed up.

We also have a current example of this limitation in the UFO's. The hypothesis that UFO's are extraterrestrial spaceships of some sort confuses phenomena and origin of phenomena. Most of the studies to find out if we are dealing with a phenomena are so contaminated with the emotional reaction to the idea of extraterrestrial origin that we do not find a clear approach to establishing the validity of the phenomena. These are examples of contamination between validity of the phenomena and hypothesis to explain.

Another prejudice is that we frequently reject phenomena for which there is no ready hypothesis to explain it, Extra Sensory Perception, synchronisities are examples of things that we tend to reject outright because it is not possible with our present constructs to come up with a hypothesis that doesn't knock over some existing theories. So we get this syndrome of phenomena to see whether we are in trouble because the phenomena have not been established or whether we are in trouble because it is not possible to make a hypothesis. We can look at various degrees of this with a higher resolution a little later.

Another limitation is arbitrariness in the choice of the depth of field and the resolving power we use in establishing phenomena. Let us imagine, for example, that we are from some other planet. We come to the earth and we are looking at the atmosphere. We want to find out about storms, what is this phenomena of a storm. The answer depends on what spatial resolving power and temporal resolving power we use. Our own meteorologists have two networks. One is a local network, which essentially is for practical purposes a horizon view of the sky and then there is a network of weather stations scattered over the country. It was only when the satellite observations were made that we discovered many meteorological phenomena that were of a scale too big to be seen from horizon to horizon network,and too small to be picked up by the nation-wide weather station network. We have here these two filters and a lot of phenomena may slip through the nets because we don't have the right sizes of filters, either spatial or temporal. We can lose certain patterns by the way in which we decompose our observations or distribute or deploy our observing stations. This is a problem of how we select our data. The old question arises; if you have a set of data to analyze, do you begin to filter it before you start your analysis and thereby rule out many data points that are considered to be no good. UFO work is an example of this. Should we take all the observations and sightings of UFO's and look for a pattern, or should we begin by going through them one by one, weeding them out and then trying to look for a pattern in the two that you have left. Well, I maintain you must search at all levels. You should look for pattern in all sightings. They you downgrade or pass them through the filter for the pattern that is left, and so on down. If we pick our route, filter versus pattern, in an arbitrary way, we can almost end up proving or disproving anything we wish by picking any route through size of net or filter.

Also there are groupings in the natural order. Stars are naturally grouped in galaxies, it appears, but we could, by taking certain size of cells for counting stars, obliterate the phenomena of the galaxy. This isn't done, but there are debates between two schools of astronomers who pick different sizes of cells and different statistical approaches to prove or disprove the existence of clusters of galaxies. We need sharper methodologies for handling this limitation. To sum up, we may miss phenomena if we decompose the observations improperly.

Now another limitation is that we think diadically, that is, most of our study of entities and relations between entities involves a single relation between a pair of entities. All of our equations are essentially a left member and a right member with an equals sign between them. Thus, we reduce all relations to a diadic relation. You can think of mathematics as a form of abstraction which is very successful in representing those relations that can be reduced to a diadic. The essential relations in mathematics are equivalence and ordering and practically all other relations are one form of other of these.

Let's imagine a family as a very simple social group and consider relations that exist in a family. We have a father, a mother, and a child. We note that a family implies ralations that must have three entities. There is no meaning to the grouping called family unless all three terms are included. There is no mother without father and child, no father without mother and child or child without father and mother. Whenever you break down any part of this grouping into three diadic relationships, you lose the real essence of family, but we do not at this time know how to treat triadic relations. We have no symbolic or mathematical way of going into triadic or more complex relations. We try to do this with subterfuges but it is a real limitation in our thinking.

There is another illustration of this. Christopher Alexander has written a paper which I recommend to you,called "A City Is Not A Tree." In it he says that designers cannot think in a more complicated structures than trees. A tree is the most complex way of looking at the world that we have available to us. To go to more complex structures such as semi-lattice structure, and really operate with them is impossible. We can conceive of them and name them, but to think with them has been impossible and this is why any city that is designed by a designer always ends up as the place no one wants to live. It's an old folk's city, or factory town, or leisure world but its sterile.

Another prejudice or limitation that we have is this tendency to smoothe. If we take a set of data we think we can say something about it if we form an average or get the standard deviations or some higher order of components and so on. But in doing this we are throwing away a lot of the information. One of the places where smoothing is done is in cosmology. When people discuss cosmology, instead of taking into account the fact that matter is grouped into stars and galaxies, they assume a perfect fluid; that all matter is distributed through the universe as though it were a perfect fluid. When they try to account for the structure of the universe, well, you can't get any structure out of such a model, and they have gotten lost between the beginning and the end. Harrison has published several papers pointing this out, I can give you some references to that. Another example is that engineers frequently design bridges and dams on smooth data such as average rainfall, when it is the peak rains that really count. But we have this tendency to look at the averages and to smooth data because it simplifies our task.

Unwarranted generalization is another limitation which can be classed as a prejudice. We make leaps beyond which our principles really permit. An excellent example of unwarranted generalization which is current is the prejudice against the medical practice called homeopathy. It has recently been shown that if you take a solute, sodium chloride or some simple solute, and dilute it as follows, say you have 100 cc of solute, and you take 1 cc and dilute it with 100 cc of water. You thoroughly mix this, then take 1 cc of the mixture and dilute it with another 100 cc of water and thoroughly mix it, take another 1 cc of this mixture and thoroughly mix it with another 100 cc of water, and so on. Repeat this twelve times and you have gone beyond Avagodro's limit which means that the probability that there is a single molecule of the original salt in the solution is practically nil. You have just water by the time you have diluted 100 cc to lcc, twelve times. Theoretically there is none of the salt present in the solution, But homeopathic physicians back about 1820 found that by taking medicines and diluting them in this way, the medicine was still efficacious. This contradicted our medical practices and homeopathic medicine received severe criticism. Although it was still practiced, it was never respectable. Recently some experiments have been performed in which instead of using people (you can always say that the procedure has a placebo affect on that and you can hypnotize people into saying that the medicine worked for them), the subjects used where chemical molecules. Today we have objective methods of testing dilute solutions with nuclear magnetic resonance, and these experiments find that the resonance lives are still present in these dilute solutions. Avagadro's limit has nothing to do with it. So because of extrapolation from Avagadro's limit, western medicine concluded there can be nothing in homeopathy. But now there is another hypothesis that comes in. Maybe the salt creates a structure of some sort in the solution and this structure has a lifetime of its own. On the basis of this hypothesis you can begin to consider that homeopathy does make sense. Part of this work, the work of over a century, has not been acceptable because of the psychological factors in using humans as the control. With this auxiliary test equipment of nuclear-magnetic resonance, we can use solutions in the laboratory for control and include the homeopathic hypothesis. Unwarranted generalizations then stem from an emotional component and are prejudices.

Now we come to a limitation which I am afraid we can't really get rid of. I think it is intrinsic. This is one that particularly plagues the social sciences more than the physical sciences and it has to do with the reports of observers. If there is an accident on the street corner and the policeman arrives and asks all the witnesses what happened, he gets as many stories as witnesses, and they do not jibe. There is no way of establishing what really happened, you just get a mean. Tolstoy was interested in this and in his novel, "War and Peace," he gave an explicit summary of this situation. If a visit were paid to all the troops immediately after a battle, or even on the second or third day after a battle before any reports are written asking all the soldiers and all the officers, lower and higher, what happened, they will tell what they experienced and saw. They give a confused, high-flying, endlessly varied, unclear impression. On putting all this together, no one could possibly learn what actually took place. But in two or three days reports are prepared and soon everyone begins to relate what happened — not what they saw, or just what they wanted to see, — but what the first reports say happened. Finally a general report is put together, and from this report all participants form their impression. Everyone is relieved, their doubts and questions are answered and supplanted by this untrue, yet definitive report. Within a month or two, if you ask a person who lived through the battle about it, you will not get the feeling that any live material is being presented. He will sound like the official report, no matter what he said originally. I did not mean to imply that the physical sciences don't have this same problem but it is especially a problem of the social sciences. Wherever there is a human being, no matter how careful, you have this Tolstoy effect.

There are other limitations — we have axiological or value prejudices. Sometimes scientists are more interested in power politics than they are in getting at the truth, and these kinds of values have an effect on the results. I worked at a place once where I was asked to work with others on a study for the military. The director of the study said as we started, "What is the answer that General So-and-So wants us to come up with in this study?" But these are blatant things, and I don't think that anybody is fooled by these. Stites, the former President of the National Academy of Sciences, feels there is something like this going on in the study of racial differences. If there are real differences between the races such as genetic differences it would be impossible for a scientist to study this question because there is so much emotion today on this issue. If one did, his reports would probably be used to burn him at the stake.

Then we have a report of scientific finding that has a short feedback loop. The Kinsey survey made several years ago illustrates this. If Kinsey were to go back and make a survey today, he'd find quite a change. What invalidated the Kinsey report in part was the Kinsey report — having a feedback loop. Reading all about sexual mores changes sexual mores. This is why child psychology doesn't work on children anymore, they have read all the books and they know the vocabulary so the dictums, what to do if, are vitiated.

Other limitations and prejudices are linearity and rejection of higher order terms. The classical example here is Velokofsky and the Harvard Observatory astronomers. I guess most of you know the story so I will only repeat it very briefly. Velokofsky's methodology was to examine myths of ancient peoples all over the world. He went around and collected legends and myths. When he found a pattern that appeared in several myths he accepted it as hypotheses. For example; he took the Hebrew story of Joshua where the sun stood still in the sky as complimentary to the story in Melanesia of the night the stars stood still. He figured those two kind of fit together and accepted it as a hypothesis. By working this way he put together a model of the planet Venus. His model claims the planet Venus was originally a comet, or at least it was not a circular orbit as it is now. It was captured and locked into orbit about six thousand years ago. The Harvard astronomers took great pains to tear Velokofsky apart and show that on the basis of the laws of celestial mechanics, this would be absolutely impossible. The stability of the solar system did not permit this kind of thing, but Velokofsky pointed out that certain ancient peoples did not mention Venus, and this was something that no one would miss because it is so bright. It only started appearing in the records of ancients at a certain time much later than records of other planets.

Just a few years ago, Schroedinger pointed out, that if we include the higher order terms in the equations of celestial mechanics, then capture and expulsion of a body becomes a highly probable event compared to leaving these terms out. I am not saying that Velokofsky is right, but I am saying that the Harvard astronomers had forgotten that they had been working with the first order terms so long that they were dogmatic about their results. This is a limitation of habit of thought, rather than an intrinsic limitation.

Other limitations we will just briefly mention. We deal with many phenomena where we only have a very small sample size available and we can't use the inductive cannon. Usually, when we get into this situation, we just have to abandon the phenomenon, we can't do much with it. Another thing is that if you find patterns in new data it is acceptable, but if you go back to old data (Velokofsky, for example), and find something that people have missed, it is not accepted. How could that have been missed for all this time. This has to do with people's ego. We also should mention while we are on this subject, our heritage from Newton. Newton solved a lot of the epistemological problems of his age by saying what we can say about the world is a mathematical formulation of relationships between entities, like positions of planetary bodies with time, or things of that sort. We ask, what is gravity, where is gravity. Newton answers, "I do not form hypotheses, I don't tell you what gravity is, I don't have to tell you what gravity is, I don't know what gravity is, it just behaves like this equation says." Today we settle for this and this was a very wise step. But we must remind ourselves that this puts a ceiling over what we are trying to do in attempts to explain. If we try to do what Newton did, we sometimes close off doors of exploration.

We can now mention at the end of this particular session, a couple of perceptual limitations. One of these is illustrated if we look at a bicycle wheel. When it is stationary, we see the spokes, and when it is moving at a certain speed we see certain patterns in the spokes, and when it is moving very fast, we don't see spokes at all. There is much of the world around us that is operating in different characteristic times from those of our senses so that we have no idea they even exist.

We are all familiar with the model of the boron atom. This table is made up of such atoms that move very fast. We can conceive this as a model, but we do not perceive it.

Now there is a very curious aspect about characteristic times — characteristic times in the phenomena we sense and characteristic times of our perceptors. This is that most events that are changing are either changing too fast or too slow for us to perceive them. We can look at cloud patterns and if we are patient, we can see changes, but in general, the changes are too slow to keep our attention. We can watch a drop of water falling and splashing on the surface but it is too fast for us to see the change of form that is going on. Now that we have time lapse photography and high speed photography we can perceive this change of form. It is perhaps something like a lava lamp which fascinates people. We could sit and watch this change of form because the change appears at a rate that holds our interest. It is not too fast or too slow. Think about this for a minute -- if we lived in a world in which everything was like the lava lamp, we would have an information overload that would just knock us out. We could not handle all of it. The thing that would attract our attention and hold our attention would be rather all consuming. Is this the clue then to the fact that we have intrinsic limitations in our perception of the world.

QUESTIONS/AMPLIFICATION II: Seminar I: Frontiers of Epistemology

(324) **J. Stromberg**: I would like to ask a questions for clearification. Am I correct in understanding you when you talk about nature and the natural order and the structure it has, that youre stating that you believe there exists an independent structure, nature, whatever,... something that exists independently of you or me. That is it is ~~not~~ something other than our perception of it or our interactions with it?

A.Wilson: Yes, this does need clearification, although this question has been debated for centuries whether we take the position of Hume, Locke or Berkeley. Whether we are talking about the structure existing here or out there . Is there some sort of dualism and so on. The point I want to make is not really dependent on how you resolve this mind-matter problem, but rather a parallel structure between a set of operations we do on the Natural Order, whatever the natural order is....things we do with our hands, testtubes and so on and how we set up a set of symbols to map those. I will want to get into this question of the implications of our metaphysics for our epistemology, which is the question you raise, but I think for the moment, we can just say it has two aspects. One is the aspect of our symbols to represent it , The other is the aspect of our sense experience. What the ultimate nature of these are, we won't go into now. I don't want to go quite that deep for now. Will you settle for that? (338)

(360) **B. Miles**: On the matter of the frog boiling and concluding we are subject to manipulation, couldn't we also develop biological adaptation?

A.Wilson: Yes, and we could hope that our children would love smog.

(384) J. Stromberg: We can look at two things and decide whether they are different or the same. I believe, two things, by definition are always different. We choose to look at the world, whatever that means, in terms of same/different.

A. Wilson: You're exposing the punch lines. This is a very important point and I want to go into that in detail later. When you have just two things, when you have three, whether the universe is a Pauli universe where no two things are exactly alike and so on

(407) V. Gradecak: For clearification, aren't we assuming that the basic ability of mea , primitive man and modern man are the same? I seem to remebber observations reported by others that this is not a valid assumption. Primitive man and/a given man only two thousand years ago had different abilities in his inate sense perceptions than the modern man has. Consequently his thought processes, like that of a dolphin were different in primitive times than they are today. And sometime shouldn't we devote some time to that question?

A. Wilson: Let me comment as follows: theres no question that they're different, but when a stream starts down the side of a hill, what happens in the first few seconds, the path it cuts, that little rut later determines the course of the stream. And what happened originally has played a deterministic role in what we have become. Now, this isn't just surmise. We have some laboratory studies. In the past year, Donna has held several workshops in which we have investigated this very question. We give people data in the form of cards on which are printed items describing experience and we ask people to structure this data. One must start ab inition, just like the primitive man. Each is to put these together in some way that appeals to them personally. Everybody in the room does it differently. But the next time, if you take one of these sets as a pre-structure and give it to other people, they build on it and what they do is determined by what you give them in the first place. We are in some sense derivative from this guy sitting under the tree with his piles but it doesn't mean we are the same by any means. No more than the operation of integration is the same operation as scooping up some nuts in a pile. Theres a big difference, but one has evolved from the other.

(427) J. Stromberg: I think that youre telling us a myth about the primitive nature of the thought of people today. I think its a useful myth or metaphor, but

Voice: It was so stated in the beginning.

Stromberg: Well, ok, but I'm sorta attached to some other myths and metaphors ....

Wilson: Good, I hope you'll describe yours later. I don't want to give too much time, then since it is a myth but there are some other statements I want to make about it. One day...............

(516) J. Brown: I'd like to mention this thing you said about the frog. I think the only things we are ever aware of ~~xxx~~ is the change in our life.

Wilson: Yes, thats the Weber/Fechner law.

Stromberg: Sounds like ancient Chinees philosophy to me. The I-Ching.

J. Brown: Do you have an alternate to that?

Stromberg: No, I was just saying that he calls it the Weber/Fechner law, I said it sunded like the I-Ching to me.

Williams: Possibly an alternative myth to go along with the one you've got is what Voya was mentioning. In primitive man's case, he had well developed senses and he had a very good sense of the environment and how he interacted with it. As he moved out of that, the contact with that environment dimished and today we've lost a great deal of that sensitivity about our feeling. We put out money for food instead.

Wilson: Yes, going back to Easelen, we find they are trying to recapture some of this.

Voya Gradecak: I would like to relate a few scenes from a movie I once saw. It was about some Australian aborigine who is considered to be the oldesnt known primitive persons who are non interacting with other races. Some of the sceses that were fliting through my mind as I was listening to what primitive man does or might have done when confornted with piles of rock were different. Let me tell you what I saw. He was using a stick, he was a very lean man, perhaps six feet tall, spindly, almost skeleton as a natural appearance. Tremendous bushy hair, a big head, and he was singing in a chanting way and he was rhythemically hitting the ground with this stick. He was performing a magical act. He was invoking gods. This was his first concern and it was all in connection with his young charge a boy, age thirteen who was to be initiated into manhood.

The way the cermony was performed it included a great amount of suffering on the part of the boy. To be taken with equnimity, because in the face of gods, you do not fail. If you do, you are through. Matters which are far more close to the primitive man -- dancing, divining, magical acts - reaching for the gods all the time. So they have learned how to survive in the Austealian desertalmost naked. They wear almost nothing, man and woman alike, but winds are fierce and nights are cold. They have no water, the land is arid, but they know how to survive, while white man with all the equipment perishes again and again. And so they are not concerned beyond this point of survival and infinite perception of what is divine. On close contact with Western civilization, they usually perish. So they are not left unto themselves. They are not civilizable. Something to think about.

Wilson: I think you have achieved the greatest bit of one-up-manship by pointing out what we have been discussing here is/really ~~simply~~ a very, very special case. The totality of things that humans can do and don't do in our culture anymore. Perhaps we should at some time in this series look into this direction. I'm very empathetic with what your saying, but I feel we have to go from the very concrete and reductionist culture we live in and try to open up in every way. The avenues your speaking of are some of the most important.

(565) B.Miles: Is it saying the same thing that we're looking at a strickly rational point of view -- we are looking at a development that had some other behavioral faculity?

J. Brimsley: Since we've practiced reductionism since,,,,we'll our recorded history is a result of reductionism,the myth I would suspect, or rather offers the question of whether or not the myth too isn't a product of the reductionism it describes. (Wilson: Yes, just as Voya so beautifully has shown) So, what was the real myth? Did a rock fall on his head or did he touch a flat slab and all of a sudden, he knew? It would be fascinating to see an alternative myth, hopefully a conflicting myth resulting from some other practice other than reductionism.

J. Gauger: Can we construct a myth that says, instead of Isee, I feel or I smell. The totality.

Voice: Lets not leave it with perception, how about I love, or I desire or I ,

Brimsley: It seems like its another construction. You base it on the same evidence on which we've based this one using the same procedures.

M. Stein: But the point is there are many modalities of being and experience, the rational is only one

J. Gauger: Is not what you term rational, a function of the sense we use the most , the eye? We don't use particuaarly, the touch, the smell, the hearing, The dolphin however, uses hearing and he developes a different way because of the sense he's using.

M.Stein: I'm wondering if theres a bases for knowledge other than the rational.

J. Brown: The aborigine is rational, because he survived.

M. Stein: Well, his god gave him knowledge. Doesn't God give us knowledge? They don't anymore.

J. Brown: It may be irrational to us, but it must be rational becase he survives.

Brimsley: I don't know whether he is rational or not. The point is we're both survivable.

J. Brown: Well, we may not in this environment.

A. Wilson: Well, there are many bases for knowledge. We can say that knowledge is a pattern that's a priori in us. We do not discover, we do not invent, we recollect. we remember. The sense experience triggers a memory and what goes on out there is suddenly mapped on something thats in us. Theories of that sort have been proposed. Thats irrational, but it has to do with knowing that is independent of sense data.

Stromberg: Thats not irrational....(Wilson: Yes thats right, its transcendental sense data)...well, its non-consenses at the moment in the intellectual establishment.

B. Parkyn: Theres an article in the latest Science New Letter that makes that point, that neurologists are starting to think that. That because of all these culture maps we have, you see something interesting and it turns one map on.

Wilson: Well, I think the spirit of what we do here has to be speculative. We are trying to free ourselves of a party line and we can't be dogmatic. I think any alternate ideas -- far fetched or not -- are grist for our mill.

(603) V. Gradecak: I would like to make just one suggestion. In addition to being speculative, if we could in a free spirit, investigate .... If we could contribute as we come across observations of very unusual observations of record. In order to base speculation on something that apparently is subject to observation, that does not fit or refuses to fit the ....of present knowledge. To mention a few exapples: The recently published book: "The World of Ted Sirios" by Eisenbud.

Wilson: Let us make xx it a homework assignment to bring in these teferences, to make a file of all these phenomena which establishment epistemology falls on it face with.

Voya Gradecak: I would strongly recommed the paperback books of Charles Fort, 3 or 4 volumens, specifically"The Book of the Damned"

Wilson: Such a collection would be very useful because we can find the epistemological base to confront every one of these, we've failed.

J. Brown: Is anyone here aware of this guy who runs his hand over the stomach and an appendix comes out? I can look that up.

J. Gauger: This weeks, Time in the science section has a write up on ESP including the work at Boing.

V. Gradecak: Oh, yes, it comes to mind, a long physician, Walter Kilner published a book in the twenties called Human Aura. It describes his chemical experimentation involving perception of human xxx aura and he later did diagnostic work using these methods. Subsequently, Oscar Bagnell

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III Structure and Process

6 February 1969

Our discussion of structures must begin with realizing we have no general structure theory.

A general structure theory is what we may call an axiomatic theory where we would have a set of axioms and theories governing structures of all parts. This is a long way off because today we have no general structure theory. In fact there's an argument over whether or not such a theory is possible, but at least we know there are certain sub-areas that are operable to general structure theory.

First of all, we may ask how a general structure theory differs from set theory. A structure in a very general sense can be thought of as a dichotomous set. Now a set is a group of entities of some sort, the elements of a set can be quite heterogeneous, but they are considered to all be elements. In set theory, we seek to determine relationships between these elements. The principle relations are ordering relations. Elements are contained in subsets and the elements within a set or sets themselves can be ordered. This essentially is the extent of relationship that is discussed in set theory.

By a general structure we will mean a dichotomous set and this means it is essential to consider at least two types of elements. These two types of elements must be kept distinct. We will call one of these an entity and the other a relation. In ordinary structures that come to mind such as static structures, you have links and nodes. Or a structure such as a transportation system has cities and air-routes where the cities are the entities and the air-routes, the relations. Thus, this is the principle difference between a general structure theory and set theory. I'm not saying it isn't possible to reduce structure theory to set theory, but we can develop new ideas that don't appear in set theory at all if we keep this distinction.

A few years ago, a fellow named Zipf at Harvard came up with something called Zipf's Law. He studied empiracle distributions in several very different areas. For example, he studied distributions of words in prose samples by the frequency of occurence, distribution of scientists by the number of papers they published, distribution of cities by population, distribution of incomes by size and distribution of biological genera by the number of species. He found a relation — a distribution function that governed all these quite different organizations. Now, this attracted Herb Simon's attention and he began to worry about this. If you could explain some of these distributions by a physical law and others by a social law or a biological law, then what underlies all these laws? Is there something deeper that explains all these distributions?

I might mention that Zipf's law is:

$$f(i) = Ai^{k}b^{i}$$

where

f may be, for example, the number of cities with population, i,

A, K and b are constants. K is between 1 and 2 and b is very close to unity. This can be generalized and Simon did generalize this expression. He obtained a Yule distribution which is similar to a Beta Function. But, the interesting thing here is why does this function appear in so many diverse contexts? Simon believes the answer lies in a certain stochastic base underlying all these phenomena and he tried to derive it, with some success, but, he's not completely satisfied with a probablistic explanation for the similarity of these relationships in all these contexts. So, if we return our earlier question, is a general theory of structure possible, the fact that there exists this one relation in so many diverse contexts suggest that it may be possible.

Now, we may ask the question, are we discovering structure on these observations or are we imposing structure. Is the structure inherent in our way of thinking, or in our analytical tools, and when we observe, we always run it through this mill so it comes out in this particular form. This is an anthropocentric predicament to be sure, for we have no other way, but we should certainly be aware that the search for intrinsic structure, if any, is along a path beset with many prejudices of imposed structure.

To turn to another idea now, I would like to introduce the notion that space and time are related through structure. The classical Newtonian way of relating space and time is that any structure, be it a dodecahedron, a bridge, a computer or a transportation system, is imbedded in space and time of some sort — Newtonian absolute time or Einstein relative time. But Leibnitz pointed out a different way to look at this. He said, the nature of space derives from the structure rather than the structure is imbedded in the space. We might amplify this notion briefly. We can say space — the co-ordinates of space— are simply ways to describe a structure. That is, they are convenient descriptors. But you see, as we get use to using these descriptors to describe the structure, we begin to assume the descriptors are primary and the structure secondary. Leibnitz wants to remind us that the descriptors derive from the structure in the first place and the real observable is the structure. The descriptors, the x axis, the y axis and the axis are secondary. They don't really exist. The same applies to time. Thus, if we generalize this — push it a little farther— the relation between space and time has to do with the structure we'e talking about. The Minkovsky idea of uniting space and time through the metric used in Special Relativity is only one, very special case. And we should not assume it is the best set of descriptors in which to imbed all structure. We want to return to this idea from time to time. Whether or not it's true is a meaningless question. Whether it's useful or not is an important question.

Now, let's go on to what is behavior or process. We can think of process as a structure in time or behavior as a structure in time. That is, behavior has a time component. So when we talk about structure and process we can speak of structure-process in spare time. But, we don't necessarily mean Minkovsky spare-time.

We need to go into more detail here and define structure more specifically. It may exclude certain things that we normally think of as structure and in that sense a general theory of structure may only encompass a class of structure — not all structures. It is necessary to our definition of structure to take into account many of the apparent paradoxes that arise from different uses of the word structure. For example, the question of static structures versus dynamic structures can both be considered structure if we realize structure has a time component. One of the goals of a general structure theory must be a definition that covers these various paradoxes as well as the concept of change and growth. I use the word structure to include the time component, therefore, it also includes the concept of evolution.

A bridge is a set of structures that from one instant of time to another is unchanging. The other question of medium or content has to do with the fact that a structure can be cast or made in many different media or contents. For example, one structure may be cast in bronze, in words, in mathematical symbols, in electronic pulses, and so on. The medium in which the structure exists can be varied.

But lets look in more detail at the fundamental units we began with - entity and relation. Entity seems to have three properties. I would like to enumerate these; we won't go into them at great length right now. One in closure, topologically speaking and temporally speaking. In order for us to perceive, recognize, and name an entity, it must be spatially and temporally limited. We are talking here about an abstraction that we are trying to describe and communicate. Our experience may not require that we enumerate these properties, but if we follow our guide line of trying to communicate as contrasted to experience only, we need to generalize whatever properties we can. Another way of saying this is that the general structure theory will be limited to those entities that have the property of closure.

A second property of an entity is storage. A structure is something that processe energy and information. Either energy or information is flowing through most of the structures we speak of. The distinction between a link and a synapse or a node is the amount of time the energy or information spends in a node or a link — that is, storage. In a transporation system, for example, we are moving people from city to city. The people spend a longer time in the cities than in the than in the air-route:. between cities. If we consider computers, the information stays in the memory a long time, in the register a short time. We might therefore say there are both fast components and slow components of any structure. If we want to differentiate a 'static' structure, we are really talking about a structure that has many slow components relative to the observer.

11 If we ask can we interchange links with nodes, the answer of course depends on the amount of time the energy o. information stays in one or the other. By definition then, we say a link has a shorter storage time compared with a node. One other thing that won't allow a dualism of flipping arbitrarily between a link and node and that is the spectrum of choice offered by each. A link does not allow branching . A node is the place where choices of path exist. There is one degree of freedom in a link whereas there may be many degrees of freedom in a node. Thus we can say that the third property of an entity is <u>choice</u> or degree of freedom. Now there are two other phenomenon we must discuss in connection with structure. There is a <u>traffic phenomena</u> associated with structure. Something is moving along the links from node to node such as automobiles along a highway between cities or message units along a wire between exchange..s. Now traffic in general is energy/matter or information and it usually is carried in somekind of vehicle. So we can say traffic has both carriers and content which are energy, mass or information. We can therefore define traffic as a phenomena emerging from an aggregate of carriers.

We next need to consider the notion that there are certain kinds of density associated with structures. The four elements then are nodes, links, carriers and content. We can summarize these in the chart below:

CHART I

STRUCTURES

Synapse	Linkage	Carrier	Thing Carried
Synapse	Neurons	Nerve impulse	Electrical impulse (energy)
Junctions	Girders	Molecules	Tension or compression force (energy)
Shopping Center	Freeway	Automobiles Trucks	Goods and people (energy)
Telephone Exchange	Telephone channel	Messages	Information (some energy)
Decision-making Center	Chain-of-command	Messages, gestures, tone-of-voice	Information
Stars	Fields (Radiation, Magnetic/ gravitational)	Electrons Photons Gravitons	Energy and information
Cities	Communication channels Trade routes	Messages Vehicles	Information and energy
Heart	Circulatory system - veins and arteries	Blood	Energy

You see there that we can break a great many different structures down into these elements: synapse or node; link; carrier; and content. If it's a static structure, the carrier may be a molecule and the content or thing carried a tensile force.

Now, structures considered this way give rise to four kinds of density in a structure. We can consider the input/output capability from a node. That is, the number of carriers per unit time in and out of a node. We call this ~~synapse~~ traffic density. A second kind of density is the number of nodes per unit volume. That is the number of cities in the United States divided by the area of the United States. Typical densities of this second type are: cities per 1000 sq. miles, schools per sq. mile, or stars per cubic par sec and so on. A third type of density in the number of links per synapse or node — the number of routes going into one airport, the number of roads going into one city, the number of girders in one gusset, the number of chemical bonds in one atom or whatever. A fourth density is the number of carriers per unit time along a linkage messages per hour, automobiles per hour, photos per second, decisions per day. (Type 4 times type 3 is equal to type 1, so these are not independent).

Experience indicates there exists some functional dependence between the structure and the behavior of a structure. I now want to discuss the different types of behavior a structure can have. First, we distinguish between behavior that is a compensatory response to its environment and behavior that is dynamically self-contained and derives from its internal structure.

Behavior deriving from internal structure can be differentiated into two types: a short-range processing behavior (such as the metabolic behavior of eating and digesting food) and an evolutionary or structure-modifying behavior (such as the growth of an individual child into an adult.) Now, depending on the extent to which the environment governs the structure, there may not be any dynamic process that results solely from internal structure. But, this possibility must not be neglected if we are to keep a holistic view. Later, I will show an example of how the properties of a star can be derived from the environment in which the star is imbedded. Usually, in our reductionist physics we normally consider these properties to originate within the star. So there is always the question whether we explain an observation in terms of internal structure or in terms of partly internal and partly external structure. Perhaps there are even some cases where we can explain behavior entirely in terms of external structure. I would remind us that this is a new approach because we normally explain behavior in terms of internal structure.

An example of using a holistic approach is seen in the analysis of the eye of the rabbit. Physiologists observe that a rabbit responds to movement on his horizon that is narrow and high while he does not respond to a movement that is flat and low. Many hours of discussion have been given to why this is so. The physiologists have analyzed ever bit of the rabbit's eye internally to explain this response without success. The answer seems obvious if we look at the rabbit's environment as well as his eye. The usual enemy of a rabbit appears on his horizon as a high and narrow object while those objects that are flat and low are not threatening to him. We use this illustration to show that it is not possible to explain the rabbit's behavior in terms of internal structure alone. While the response mechanism may be inside the rabbit, his behavior cannot be explained without including the environment.

The question of how far to extend the sphere around any one entity depends on what we propose to explain. As we mentioned before in discussing whether an electron displays closure, we can of course consider the electron as extending to infinity. But higher order affects neglected, we can usually cut off the neighborhood of influence at a meaningful limit. It requires we decide for what purpose we intend to discuss in order to define this neighborhood. There is a neighborhood of influence for each type of interaction.

In summarizing our holistic approach then, is it fair to say that that which is geometrically internal is not the only significant part of the structure governing behavior. Closure implys external and internal behavior. We must extend the boundary to solve the problem at hand. If the problem is purely a mechanistic one of finding the exact nature of the filter in the rabbits' eye-brain complex that passes the horizontal or vertical target, we can stay within the rabbit's eye. But if we ask where did this particular response come from in the first place, we must go beyond.

So it's possible to say that behavior is a consequence of the total structure, not just internal structure. This holistic view is more easily accepted by social or life scientists than physical scientists. The only place in physics where we find holism is in MACH'S principle which concerns the difficulty of defining inertial frames. Mach concluded that the nature of any part of the universe such as atoms are really determined by the nature of the whole universe. That is, the number of particles there are in the whole universe determines, for example, the constant of attraction. So it may well be that even in physics we must adopt the holistic viewpoint.

I want now to move into the question of time—short-term and long-term constants. Short-range behavior plays no part in modifying the structure except for aging. Long-range or evolutionary behavior modifies or changes the structure. Most short-range behavior is energy processing whereas evolutionary behavior is information processing. In short-term behavior there is an input and output of energy with some part of the energy being consumed in the processing. One example of short-term behavior is the metabolic processing of living organisms. But another example we could also consider is the metabolic processing of a star which is the conversion of matter into energy by some process such as the proton-proton or carbon cycle. This behavior also changes the structure of a star however, so it isn't a pure case. We cannot distinguish the metabolic from the evolutionary behavior in stars except that one is occuring rapidly and the other slowly.

Let's take another specific example we can talk to. If we consider the United States with various cities New York, Los Angeles, Chicago, Houston, Phoenix, etc., that are connected by air-routes, we can consider the daily metabolism in this structure as the aircraft flying according to certain schedules from city to city. The time constant for this behavior is 24 hours, that is, everything circulates in 24 hours or some multiple of 24 hours. Now, we think of the cities or nodes as rather permanent. Yet, we know that the transportation pattern affects the growth or decay of these cities. So, in another time scale, these nodes evolve or change. Eventually, the whole configuration or structure will change. And there are also intermediate processes. You could change the routing or scheduling and the integrated effect over a long period of time would be the nodal characteristic time.

So, there is a time constant associated with a node—a city comes into existance and disappears. There is a time constant associated with the operation of air traffic. There is also a communication time constant that is much faster than the scheduling or routing time constant since the communication network has to operate much faster than the operation network. This structure has at least three time constants or characteristic times.

If we take the human body as a structure, there are short time constants for breathing, digesting, etc., and there are longer time constants such as the 24-hour cycle, the reproductive cycle, the life span of an individual and finally the characteristic time of the race as a whole.

In closing our discussion on structure and process, I would like to show a specific derivation of results from adopting a holistic approach. To begin, I want to assume that there exists a relationship between traffic density and synapse density. On the basis of thi assumption, lets see what we can derive. We take the case where our structure consists of a set of n spheres with mass, m, and radius, a. The whole aggregate has a radius, r.

insert derivation:

traffic density / synapse density & velocity^3

Now, if we take this expression, Eq.( ) and substitute known quantities, we come up with the fact that the luminosity must be less than $10^{38.5}$ ergs/sec. If we convert to bolemetric magnitude, we obtain -7.45 which is what is observed. This means the brightest star in the galaxy, except for exploding stars, has this energy output. It is also known that the more massive the galaxy, the bigger the m, this number drops and that fact comes out of this equation also.

So, here in a holistic sense, without talking at all about whats going on inside the star, we have made this one assumption— that there exists a relationship between synapse density and traffic density—and we can quantitatively come up with the values that are observed for the brightest stars in different galaxies. One other thing, you can let this go to no galaxy and come up with 10^{59} ergs/sec which is the limiting energy obtained for quasars if they are at cosmic distances.

We see that this results in similar to Zipfs' Law. You can produce a lot of observables with one assumption. You understand we are not doing astrophysics. We haven't used physics at all except to use the value of c as the velocity of light. I present these results as another bit of evidence that there may exist a theory of general structure. The question is, how do we go about constructing such a theory. Presumably, these different densities may be very useful.

In conclusion, our new epistemologies or extensions must have stringent demands on whatever theories or hypothesis we devise. The requirement is that any theory or hypothesis explain at least as many observable phenomena as it contains assumptions. The question of course, is how to measure assumptions. This we don't know yet.

IV: Problem of Levels

6 March 1969

Last time we discussed structure and process. These are abstract terms. By structure, we shall mean anything from a transportation system to a human brain or an animal brain, a nervous system, a biological system such as metabolism or respiration or we may mean a star, a galaxy, or a cluster of galaxies; or we could be talking about organizations such as governmental organizations, industrial organizations, city structures; or we could mean static structures, such as bridges or cranes. The question we address ourselves to is: is a general theory of structure possible? Can we, following the path of Euclid, develop an axiomatic base for a general theory of structure? That is, from explicit postulates and axioms, can we develop a system of relations that apply to all of these structures, static as well as dynamic. This sounds like a big order but we find there are two hints that suggest it may be possible to do this. The first of these is Zipf's harmonic law. In 1949, Zipf at Harvard formulated the following relation: $F(i)$ is proportional to i raised to the power of $-p$ where $-p$ is approximately unity, and $F(i)$ can be the number of cities whose population exceeds i, or the number of words with letters greater than i, or the number of airports with traffic greater than i, or the number of people with income greater than i, or the number of scientists publishing greater than i papers per year. The point here is that Zipf's harmonic law applies to a large set of diverse phenomena. The question is how come? Why should the number of airplanes landing at an airport follow the same kind of distribution as the number of scientists publishing papers per year, or the number of words in the English language. One answer is that if there is any general or "meta" law underlying all of these structures, then the fact that Zipf's law applies to so many diverse phenomena is not surprising. Of course, it could be argued that these phenomena are simply following the most basic stochastic processes found in nature. In other words, it is not surprising since everything is a stochastic process. However, we can also look at the concept of probability as an arrangement. Probability can be considered as the ratio of the number of realizable arrangements to the totality of possible arrangements. In this sense, we would be considering the various systems following the Zipf harmonic law, from the theoretical structure point of view, rather than from the probability point of view. To simply brush aside all of these distributions as following statistical laws, would be sweeping much under the rug. We would rather consider this from the possibility of structural similarities. We would therefore like to look at these things from the point of view of possible arrangements. Zipf's law, therefore, suggests one hint that a general theory of structure might be possible.

A second comes from the notions in set theory. If we say a set must contain two types of things, entities and links, and that these are not necessarily interchangeable, then we can define four types of density. These are (1) <u>traffic density</u>, which is the number of carriers per unit time in and out of a node. For example, cars per hour, airplanes per day, decisions per week. A second kind of density is <u>nodal density</u>, which is the number of nodes per unit area or volume. For example, cities per thousand square miles, schools per square mile, telephones per building. A third density is <u>link density</u> which is the number of links per node. For example, roads per city, routes per terminal, or telephone lines per switchboard. The final and fourth density is <u>carrier density</u>, which is the number of carriers along a link, cars per mile, messages per hour, or decisions per week. These are not independent, Several can be related to one another. The fourth type, carrier density, times the third type, link density, is equal to the first type, traffic density, but if we make the assumption that the link density times the traffic density divided by the node density is bounded, we can derive some interesting results. In the case of a physical system this quantity has the dimensions of a velocity and we would take this bound equal to c, the velocity of light. If we apply this notion to stars, we can quantitatively derive the observed magnitude of stars in various aggregates. So we can take this idea as a hint that to pursue this kind of development, that is, to *ab initio* start with entities and linkages, we perhaps may be able to discover the underlying relations between entities in these diverse systems, such as physical systems, biological systems, psychological systems and social systems. So in summary, we say these two things. Zipf's harmonic law and the notion of the density bound relation are favorable enough for us to pursue a general theory of structure.

Now last week we discussed these ideas and various questions arose, some from amplification and some from other sources and we feel it would be worthwhile to look at some of the questions. First we have the question, *Is structure intrinsic or are we imposing structure on experience*. This is a philosophical question which, I think, is part of the old anthropocentric paradox. We can never really say for certain that at some level we are not imposing structure on our experience. As humans we are part of nature and as creatures of nature, we participate in the universal drive of nature to order. We might simply say that if we can utilize the structure, then why worry about it — go ahead and use it. We have certainly created structure in the body of knowledge that we call science. Whether or not this structure exists in the real world out there or only in our minds because we impose it on our experience, is a question we will have to leave to the ivory tower philosophers.

A second question that arose last time and is written on the board, Do our concepts of space and time derive from structure. We talked about that some last time, but I would like to save it for a later series where we will talk about alternate concepts of space and time, alternate to the concepts we now use in physics.

A third series of questions that arose from the amplification last week had to do with, Do we include dynamic aspects of structure in our notion of a general theory of structure. I think we answered these questions by the notions of nodes and links and the idea that associated with each node and link is a characteristic time. That is, we do take into consideration dynamic patterns when we recognize that nodes and links each have their own characteristic time. We will go into more detail with specific examples later. This discussion then will take us into the concept of level which we will get to shortly. In connection with dynamic pattern many have asked about how must we deal with the concept of change and evolution. The concept of change or evolution can be considered as different types of behavior. If we consider a human being, for example, first there are behaviors we generally think of as metabolism, breathing, digesting, heart beat, neural responses, etc. Each of these behaviors has associated with it a characteristic time. Then there is the behavior we normally call growth, which has a charactistic time, or the behavior we call reproduction, which has the characteristic time of nine months. There is the life cycle itself, which has a characteristic time of about 70 years. Next we could consider evolution of the organism, with which we are concerned and an evolutionary change is a change in the program of that organism. The characteristic time of the behavior called evolution may have a much longer time. So we have for each type of behavior a characteristic time associated with it for whatever organism we are concerned with, a human organism, a society, or a galaxy. When we talk about behavior in terms of levels we can show that the type of communication, the sophistication of the communication, and the characteristic time for communication, change from level to level. Evolution and growth are behavioral processes with longer characteristic times than metabolic processes or reproductive processes.

Another question that arose last time is How is arrangement related to the concepts of node and links. Nodes and links are basic, an arrangement is secondary. We can take an arrangement of nodes and links and create a new structure which itself may become a node in a higher level structure or a new level of structure. Arrangement is implicit in the idea of a node. We could use the idea of arrangement as a particular pattern by which we put nodes and links together. Another question that arises is Can we interchange nodes and links. In our notion of a general structure, a structure is a dichotomous set with two members. In this definition of nodes and links, they are not interchangeable. One way in which they are not interchangeable is that a node has a higher degree of freedom than a link. A second way which shows they are not interchangeable is that traffic remains in a node a longer time than in a link and therefore a node may be thought of as a storage entity and a link as a communication entity. In this sense, they are not interchangeable. One could, of course, consider a dual structure in which you replace nodes with links and links with nodes. It may or may not be a realizable structure, but the concept of duality would be permissible. We will use the word dimensionality to suggest orthogonal independence. Descriptions of nodes may require higher order dimensions than descriptions of links. For example, in order to conceive of what is a node, or what is a link in a particular system, we have to remember the characteristic time of nodes and links are different.

also
particles +
cells

In a static structure, of course, we can imagine Tinker Toys, where the nodes are connectors, and links are sticks, but in another type of structure we think of the city as a node and the air route as a link. The characteristic time for modifying the city may be very long compared to the characteristic time to modify an air route.

Characteristic velocity is also another very valuable way to distinguish between nodes and links. We have already mentioned four types of characteristic density and we must also develop characteristic velocities and get the relations between these and the densities. But first, to finish up the questions on the board, someone asked last week, Does an electron have closure. This depends, of course, upon all the different ways one can define closure or partial closure. This more properly follows a discussion of levels so we will go on to this question of closure later.

We now turn to a remark made by a historian, Stephen Tolman, who says that if you look at the history of ideas and how men for centuries have been trying to make sense out of their experience, there are two basic aspects that rise. One is the problem of interaction and the other is the problem of levels. Certainly the ancient atomists, such as Democritus and Epicurus, believed you could break everything up into atoms and these atoms could influence each other but only be contact or impact. Action at a distance is forbidden in this notion. Then historically we also have the Pythagoreans and Stoics who liked to think in terms of forces and tensions or tunes and harmonies, or patterns. This is an entirely different notion of the nature of the world. These two, the atomist and the Pythagoreans, were at odds with each other. The first great synthesis of these two schools was made by Newton. Newton took the particles and said forces can exist between the particles. His great insight is in merging these two heritages in the notion of forces between particles in his idea of gravity, and he settled for a mathematical expression to put at rest the argument between the atomists and the Pythagoreans. Now, if you are given gravity, you can explain orbital motion, or if you are given valances you can explain chemical bonding; but this doesn't explain gravity or it doesn't explain valances and our modern scientific notion is to settle for this kind of explanation. We accept the notion of gravity and from this we are able to make useful predictions, but it must be mentioned at this time that to ask what is gravity is considered to be a non-scientific question. In other words, today after several hundred years of using the notion of gravity, we no longer worry about the question of what is gravity. The important point here, however, is that both the atomist and stoic viewpoint are different strategies, different ways, to search. The point in reminding ourselves about the synthesis of Newton to combine both the atomist and stoic point of view is that we should use both strategies in considering levels. We can think of levels as the different harmonies in a tone, or we can think of levels as aggregates of atoms. We will not have to adopt an either/or attitude.

In keeping with the thesis of these seminars, the reason for examining the problems of levels is implicit in the need to adopt a holistic view point. One of the major deficiencies of the reductionist attitude is its narrow focus on entities instead of focusing on both entity and context. We might also say that the thing that is wrong with reductionism is its insistent demand to isolate phenomena and find their boundaries. Definition always implies separation. By separating into finer and finer detail, phenomena soon are stripped bare of their original rich essence. Precision in definition that results at the end of the reductionist analysis is not satisfactory just because it does remove the many faceted aspects of phenomena. One approach used currently to overcome this impoverished state of affairs is found in the methodology of phenomenology. As opposed to the scientific attempt to explain phenomena by reducing them to laws and patterns and categories of classification, phenomenology seeks an understanding of things themselves, as well as insight into their human significance. Science seeks the elimination of mystery, but phenomenology in confronting things as they are, seeks to elaborate on, and celebrate in mystery. The mystery of things existing in themselves and for consciousness alone independent both of their uses and of the stereotypes through which we normally view them. What we are attempting to do is similar to the phenomenologist's point of view but not exactly. We agree that the reductionist attempt to explain phenomena results in absurdities but rather than considering things in themselves we are saying that reality is not a solid homogeneous block. It is divided into levels each characterized by a set of properties and laws of its own. Higher levels are rooted in lower levels both historically, that is, in their origin and contemporaneously. In other words, if we are ever to gain understanding of the external world, we must seek understanding of the level structure exhibited in so many diverse organisms.

Let's begin with some very concrete examples of level structure. First, consider the number system. We have natural numbers which are usually considered to be positive integers. At another level we have rational numbers which result from solutions of algebraic equations such as $a+bx=0$. At a third level we have irrational numbers. These result from solutions of equations usually called roots -- something like $x^2=0$. A subcase of those would be the complex or imaginary numbers which are related to the irrational numbers. An imaginary number is in the form of $a+bi=0$, where i, of course, is the square root of minus one.

. A fourth level would be transcendental numbers and their chief characteristic is that they do not derive from solutions of algebraic equations — the most common examples being π and e.

I think that this is an example of levels. In other words, we are here implying that there are differences in numbers that derive from different classes or different levels of algebraic equations and their solutions. I will leave that one and go on.

We have another concrete example of the systems of levels in the biological organisms. Maybe drawing some sketches on the board will help. Let us assume that this is an organism and let's talk about biological activities. There may be many more but let's talk about system activities in this organism. We will take the one system. There is an activity A. There can be several activities going on at the same time but that is not the point. A can be activity in the nervous system, B could be something like the blood circulation, C could be the breathing system, D could be the digestive system, E could be the whole reproductive system, and F another system we could call growth and decay. Last time we did discuss something about the characteristic times of these but all I want to do at this point is to say is that in the language of the biologists that there are simultaneous system activities going on in an organism. I think those are examples of levels.

Other examples that are used and discussed a lot are such things as physical systems. Harlow Shapley is one who has spent a lot of time on this and he has charts that he is always using, beginning with the smallest fundamental particles, We then go into atoms, then into molecules, and molecular systems or crystals, depending on what you want to call them. He meant, of course, those that had built up into meteoritic associations, satellite systems, and on into the cosmic levels. We then have stars and either one of these levels could be broken down more finely, but we will just take the larger ones. We certainly have clusters of stars, galaxies, and then we have clusters of galaxies and on up to some unknown aggregate which may be the universe. Those examples are discussed all the time. I don t think there is any question about their being levels. We use it in our language.

Now some other things that may not be quite so familiar — there have been different ideas about treating levels of knowledge. Historically there is a lot of discussion in philosophy, Compte was one philosopher who thought he could arrange knowledge into qualitatively different levels, but I want to take a very specific example that is in our own working experience. Take your own experience a working idea about some aspect of your own work. First of all, this idea is probably at the level of discussion with colleagues or some kind of vague notions in your own mind which you either write down on scraps of paper or you begin to classify and to file, anyway, at one level you have something like a working paper that you may pass around to friends. While the idea is not completely formulated, it stays at that level, and as you get completely acquainted with the idea or work on it more, eventually you may consider working these into a new level. The level of information in a paper is certainly different from the level of just talking to your friends over coffee. At some other level, after this paper has been read, and maybe published in several other places, it becomes firmer and harder and you have made corrections to it, and it gets summarized in some collection of readings and finally this paper gets to the point where it is in a very different state, into the text book type of thing. In other words I think we could find a scale on a set of levels of information. In fact it has been used in information retrieval systems, grading different documents in terms of what levels of knowledge they present and what its format is. That is a common one. The examples of levels in social aggregates are so familiar that we don't need to spend any time on them -- the army, with ranks all the way from generals down to privates, is certainly a level structure. We can do the same thing with organizations, with individuals combined into families and families into some kind of kinship or neighborhoods, and neighborhoods into regions -- these are well known. Another good example, I think, that has come out more recently is levels in computer programs. At one point we have machine language, a statement which is usually a single instruction and coded so that you can make efficient use of the electronic hardward of the computer. Such a statement at this level in the language of the IBM 660 would be 5A20D00E which would specify the addition 5A with simulator 2 of data in the memory word addressed by 0D00E. That is one level of language. Of course, we all know that we don't write in this language so you have got to have something in between as an assembly language. The same statement above written in assembly language would be something like: ADD 2, Factor. Of course, since most of us don't even work in the assembly language, we have to go to procedural languages like Fortran or Kobal or whatever, and statements there would look like X = A + B - C/2. Most of you are familiar with that. That is an example, I think, of levels.

¶ There are some other computer examples. von Nuemann of course, was the first to introduce the idea of levels into the organization of computer memories. Then, of course, programs themselves are arranged into levels. Fred Tonge says that most programs in practice are hierarchically arranged as a practical means of dealing with complexity. This gets into the whole problem of sub-routines for repeated programs or repeated tasks, such as square root. Tonge also points out, however, that this is another technique for helping the problem solvers to conceptualize it is too hard to look at the problem at once. It is easier to put it down in sub-routines. You not only find the program and the data organized in terms of levels of some kind, but even the flow of the problem solving itself has some kind of hierarchical or level structure to it. ¶ There is one other little example I would like to just show you on the board. Another idea that we have been thinking about ourselves, we call this the sign-symbol spectrum, for lack of something better. There seems to be a lot of confusion in today's world, anyway, a lot of discussion about whether we are talking about signs or symbols. Now at the very low end where something is a sign I would characterize it by saying that it is very explicit, also very non-redundant, and can be easily contrived or invented. By symbol, I mean something that is very, very redundant, it is very, very rich, not explicit at all, and it cannot be contrived by humans. Now then, at the lowest level down here we can pick something that is arithmetic, we can have 1 + 2 = 3, very, very explicit. At some level above this we can have something in an algebraic expression, we can have a + b = c. But of course it could be the same as it is written in this operation, but it doesn't have to be. Now we can go up the spectrum somewhere to a place where we get into terminology in a set series, where we can have some set A and set B with some operation which is not necessarily an addition operation, and I'll leave that undefined. But the set A and set B = set c, which we can make very specific depending on how we define this combining operation. If we continue with this I think we could find levels in this kind of terminology which we use all the time. There are some questions, one of them might be: where do we put such things as trade-marks. I'll leave that for amplification. I, myself, think they are very low, near the pool of signs down here but we might have some discussion on this. All I am trying to suggest here is that in our communication, in symbols that we use to communicate with each other, we have levels and these are effective because we are able to talk and communicate at different levels. An example of a symbol, one from the Eastern religion is the mystic word, om. An example of a symbol is the cross. In Western Judaic-Christian backgrounds, we could spend hours and hours in discussion on what the cross is. It has energized humanity for 2000 years and there have been many, many things done under the symbol of the cross. I don't think this can ever by explicitly defined like you can signs. Anyway for me, the things that are symbols are very, very rich, they have many, many meanings and overlaps, they can never be defined, they are energized -- they have tremendous energy in the sense that they are motivating psychologically. I don't necessarily want to talk about symbols, I just want to say that there are levels in the way we are able to communicate with each other. Now there is one other example that I thought was somewhat useful in a paper by Maruyama. He looked at information in three different categories and he thought there were implications for information retrieval in this. He did this by talking first about classification type of information which is kind of a common mode in western science. It is thinghood. It's central question is: what is it? By contrast to classification type of information, there is relational information, which is not so interested in what is it but how does it relate to others? And finally, he has a category called relevantial information which has to do with specific concerns of individuals. It is situational and it is needed immediately for action. He gives an example of a flower — if we discuss a flower in the terms of the classificational type of information, we would discuss it in terms of its species or we may add some multidimensional classification to it by saying it is such and such a size, or it is located here, it grows in such and such a climate — all those would be classification type of descriptors. If you would consider a flower and look at it in its relational type of information, you would begin to talk about flowers in terms of a decorating the table, or it was planted by the daughter of the household, or it was part of an esthetic composition with the bush behind it in the garden, or it attracts insects which attract birds, which in turn pleases the lady next door. In other words, you are discussing not things, but the relations between things. Finally, anything that is relevantial information has to do with concern, like, does she love me? Or should I commit suicide, or would they trust me if I did that? Or there must be some person in this world who would be willing to marry a person like me. How do I find that person? For him, How do I find that person, is a very highly relevant type of information. In our terminology, we would talk about classification type of information as imposed structure; relational information as instrinsic structure, and then relevantial information we would call instrinsic plus value — it contains value or purpose. Again, different levels.

Now the interesting thing about the examples I have picked out is that some of them are trees and some are not. In just a bit of a review of a paper we have discussed several times here by Chris Alexander, I would like to mention two things about trees and semi-lattices. A tree is a collection of sets, or rather a collection of sets forms a tree, if and only if, for any two sets that belong to the collection either one is wholly contained in the other or else is wholly disjoined. If we have 20 elements in the arrangement of a tree, we can get 19 subsets. Now if we have a semi-lattice, that is, a collection of sets is a semi-lattice if and only if, when two overlapping sets belong to the collection, then a set of elements common to both also belongs to the collection. In other words we can have many many overlaps and if we start out with the same 20 elements we can find up to a million subsets, making all the possible overlaps. The point for us here, at least for Chris Alexander, was that tree structure includes the possibility of overlapping sets. This has come up several times in our discussion. Trees are trivial examples of semi-lattices — true, but they are very restricted. The tremendous variety and the greater relational complexity of the semi-lattice is much more interesting to us and that is why in Alexander's work he does not want to design things like a city on the basis of a tree. It cripples all the possible overlaps that you could have. A tree structure means that within this structure no piece of any unit is ever connected to another unit except through the medium of the unit above it. It is a little like insisting that the members of a family are not free to make friends outside the family except when the family as a whole has made a friendship. You can see how restricting that would be. That is all I wanted to say about these two kinds of structures.

Back to our question now that prompted us to return to levels again, are levels imposed or are they intrinsic. One aspect of this problem of implicit or intrinsic levels could be illustrated by going back to the distribution we discussed last time in Zipf's harmonic law.

Here we want to discuss the differences between the distribution functions of Zipf's harmonic law and the more familiar distributions called Gaussian, Poisson, or s-growth curves. Basically in a Gaussian or Poisson distribution we are plotting individual elements versus some characteristic of those elements. For example, we plot the number of individuals in an aggregate against their height, or against their weight. A Poisson distribution is really the same thing. There, we are plotting frequency against some characteristic. In a s-growth curve, we are also plotting the number of elements, such as the number of people in a city, or the number of bacteria, against time and we get the familiar s-shaped curve. Now in contrast when we take this harmonic law of Zipf where we plot some function of i, such as the number of cities with population i against the population i, we find there is always a distribution that is a hyperbola. Another way of saying this is that there are few cities in any aggregate of large population i and a larger number of cities with smaller population. Now at first glance these two generically different distributions, Gaussian or harmonic, appear to be different in the sense that one is concerned with elements of an aggregate against some characteristic of those elements, and in the Zipf harmonic distribution, we are concerned with elements versus the aggregate as a whole. Is this something that may help us answer the question of intrinsic versus imposed? Well, let's examine this idea. This apparent difference really doesn't hold up because we could, in effect, use a Gaussian distribution to plot the number of cells in an individual's body instead of weight, and in that sense, we would be plotting aggregates versus elements of that aggregate. However, there is an interesting aspect in considering the differences between Gaussian distributions and Zipf's harmonic distributions.

We note that in Zipf's distribution the curve goes on off to zero, whereas in Gaussian distributions the curve does not go to zero. This, in effect, is saying that below some critical number of cells in a man's body or weight, there is no meaning to the definition of man. Or another way of saying this is in Zipf's law, all sizes are possible, even one or two cells, whereas in Gaussian distributions not all sizes are possible, there is a limit. This difference might perhaps be worth thinking about. There is an analogous argument in the astronomical community concerning the number of stars that comprise a galaxy. Hubble and Homberg and others maintain that galaxies consist of 10^{12} stars as a maximum down to about 10^{8} stars. In other words, they insist that there is a Gaussian distribution to the number of stars in an aggregate called galaxies. On the other hand, Zwickey maintains that the number of stars in a galaxy is not limited. Here we are talking about the number of elements in an aggregate. Zwickey maintains that a galaxy could consist of only two stars but the paradox here is that there is no way to observationally check the number of stars in a galaxy below this limit. In other words, we cannot find out if Zwickey is right because galaxies composed of fewer than about 10^8 stars will not be observable with our present telescopes.

The reason for the differences between Gaussian distributions and Zipf harmonic distributions is that we see clearly the idea of bounds or limits to maximum sizes. If we think of social aggregates, for example, there must be some limiting size for social aggregates. By maximum, we mean some size that is most optimum for survival or is most viable. These kinds of considerations might give us some clue in establishing these bounds or limits. This whole area of looking for limits might be a useful area to examine.

In summary then, perhaps one good place to begin in studying aggregate phenomena would be to look for limits. We can follow the analogy of the usefulness of using limits such as the velocity of light or potential bounds from physical systems.

In this seminar we have shown examples of level structure. We have pointed to the fact that some of these levels are trees and some are not, and we have raised the question: are levels intrinsic or are they imposed. This question may lead us to answering what aggregate sizes are viable and what limits exist.

V: Hierarchies and Polyarchies

13 March , 1969

By hierarchy, we shall mean a set of related levels. The relation between levels may be one of control or restriction, or boundary values. Several different writers have formulated definitions of hierarchy. Pattee defined a hierarchy system as a"complex association of elements which are decomposable into subassemblies, such that some degrees of freedom of the subassemblies are subordinated or constrained by the dynamics of the total system." Another definition of hierarchical system given by Simon is a system "composed of interrelated systems, each of the interrelated systems being in turn hierarchical in structure until the lowest level of elementary subsystem is reached." The historical etymological definition of hierarchy refers to a complex system in which each subsystem is subordinated by an authority or dominance relation. Rosen defines a hierarchically organized system as "one which is a) engaged simultaneously in a variety of distinguishable activities for which we wish to account, and b) such that different kinds of systems specification or description are appropriate to the study of these several systems." Rosen claims that it is the second property b) which is decisive for a hierarchical organization, that is, a system may be doing several things simultaneously but if the same kind of system description is appropriate for all of them, the idea of a hierarchical organization does not arise.

If we ask, why hierarchy, why this particular arrangement, we must first consider whether the observed hierarchic structure is real or apparent. One obvious explanation is that we observe things hierarchically. Many examples in the study of human cognition serve to illustrate this. The necessity to organize hierarchically seems to be related to our capacity for processing information and memory. In order to memorize a list it is necessary to order or to impose structure (Ref. Bruner, 1960). There are limits to the number of concepts anyone can consider simultaneously (Ref. Miller, 1963). The recognition of pattern in ambivalent figure ground images requires a hierarchic processing between levels of detail (Ref. Maslow, 1963). In observation of astronomical objects, there are other examples that require differentiation between apparent or real (Arp's diagram, visible or invisible matter in the universe, Zwickey's luminosity function). If hierarchical structure is real and not a cognitive feature of the observer, then what underlying causes can we posit. Hierarchy may result from some optimization, such as processing time, economy of representation or description.

To make this clear a type of hierarchy very frequently encountered is what we may call modular hierarchy, that is, the hierarchy whose levels are identified with stable, semi-autonomous modules that are composed of lower level submodules and that are assembled into higher level super-modules. Familiar examples are molecules composed of atoms and assembled into crystals, words composed of letters assembled into sentences, platoons composed of squads assembled into companies. The advantages of modular hierarchical arrangements include both allowing for the necessary time to complete extended processes that may be interrupted and the ability to cope with extended growth. Another economy is realized in modular hierarchic structure in assignment of symbolic characters to represent large numbers. If we want to represent all numbers from zero to, say, 10^{40}, then hierarchical arrangements are required if we want to minimize the number of characters used.

Rather than ask what causes hierarchy we might also inquire into the origin of hierarchy, that is, instead of asking does _a_ cause _b_, we look at the existence of hierarchical structure in terms of a gestalt effect. Here we consider _is hierarchy convergent or divergent_, that is, is it a result of aggregation of elements into a whole or the result of fragmentation of a whole into elements. If divergent,are the resultant sets of elements uniform or unique? A uniform set of elements resulting from fragmentation would be some whole composed of identical elements like the tiles of a floor. Another possibility for fragmentation is some whole composed of elements that are each different, like the tiles of a mosaic. We might also approach the question of the origin of hierarchy by assuming the notion of modular hierarchy or modularity as basic and derive physical laws from this. Modularity may reflect initial conditions and therefore, it is a result of becoming, or modularity may reflect boundary conditions, if so, it is a result of being. So if we continue to be concerned with what are the causes of hierarchical structure, we may be able to answer this if we ask instead, what are the properties of hierarchical structure, keeping in mind there are at least two generically different types of hierarchical structure. One of these we will call modular or repetactic hierarchy. This is a hierarchical structure that results from iterated modularity. The shape of a crystal is the same as the shape of the molecule out of which the crystal was made. The isohedral shape of two aggregated elements in geometric space packings repeats itself at every level of closure. The second kind of hierarchy results from principles or forces that are completely outside the properties of a particular level and its elements. That is, an entity on any level is defined and characterized by neither the context nor the content of other levels. For example, if we ask why a star (and stars are one level in the hierarchical aggregate of cosmic matter), two typical answers are usually given. Either a star is a result of the properties of the atoms of which they are composed, or a star is the result of the nature of the universe. Both of these answers explain the star level in terms of content or context. Astrophysics always uses atoms to explain stars, not stars to explain atoms. Another possibility is that a star is defined by something outside both atoms and the universe. A star can be defined by a potential limit and an accretive force like gravity. This type of hierarchy is generically different than modular or repetactic hierarchy.

Let us return to the statement made above that one advantage of hierarchical structure is that it allows us the necessary time to complete complicated processes that may be interrupted. In Simon's paper, "The Architecture of Complexity," we find the fable of the two watchmakers, Hora and Tempus who demonstrate the advantages of modularization. Hora builds watches in modules while Tempus assembles watches element by element. Hora prospers while poor Tempus eventually goes out of business. Why? The reason is found in the fact that although both are interrupted by phone calls and customers, Hora need not resume each time from scratch. The advantage of modularization thus induces Simon to argue that complex systems evolve far more quickly when they are organized hierarchically.

Another idea associated with hierarchy is that hierarchical structures are nearly decomposable. That is, interactions *among* subsystems are relatively weak compared with interactions *within* subsystems. This facet not only greatly simplifies their behavior, but it greatly simplifies the description of complexity. In a nearly decomposable system the short-run behavior of each of the component subsystems is approximately independent of the short-run behavior of the other components. Also, in the long run, the behavior of any one of the components depends only in an aggregate way on the behavior of the other components. Let us look at an illustration of this by considering the following diagram. The figure below represents a building whose outside walls have been thermally insulated from the environment. In other words, it is a perfect thermal insulation. We take these walls as the boundary of the system. The building then is divided into a large number of rooms, the walls between them being good but not perfect insulators. The walls between the rooms are the boundaries between our major subsystems. Each room is also divided by partitions into a number of cubicles and the partitions between cubicles are poor insulators. There is a thermometer in each cubicle. Now suppose that at the time of our first observation of this system, there is wide variation in temperature from cubicle to cubicle and from room to room. The various cubicles within the building are in a state of thermal disequilibrium. If we take temperature readings at a later time, we find that there will be very little variation in temperature among the cubicles within each single room, but there are still large temperature variations between the rooms. If we take readings again several days later, we find an almost uniform temperature throughout the building. That is, temperature differences among the rooms have virtually disappeared. The corresponding matrix which represents this hypothetical situation is also shown in the figure below. We note that the matrix entries are the heat diffusion coefficients between cubicles. Cubicles in a room that is a1, a2, and a3, have high coefficients as do the entries in the cubicles of the room of b and the entries in the room c. We note that the high diffusion coefficients lie along the diagonal of this matrix, whereas the diffusion coefficients between rooms are very low, two or one. In classical systems we usually ignore entries that are this low in comparison to the main diagonal. However, in hierarchical systems we must introduce the off-diagonal entries. Thus we can use this as an example or representation of the concept of semi-autonomy. The point here in the heat flow in this schematic diagram is that it is an attempt to treat two levels simultaneously and we note that most of our normal physics does not do this. Or in other words, this is how a matrix which is trying to treat two levels simultaneously would look.

Next we can talk about hierarchies of control systems. Bunge has said that all hierarchies are structures of levels related through the relation of control. We need to consider arguments for and against this hypothesis. We can keep this assertion in mind but we will also consider control hierarchies as well as hierarchies in which the relation is not that of control. By control hierarchies we mean such things as a boss giving orders to a straw boss, who then gives orders to others, etc., or we can talk about control hierarchies in which there are feedback loops, such as servo-mechanisms. We will later illustrate that these control hierarchies are similar to hierarchies in which the relation is one of gravity and this fact is rather surprising. Both can be characterized by two properties; the first is the number of subsystems involved, and the second is the characteristic times.

To suggest another facet of why study hierarchical systems, may I suggest a homework problem.

Consider all the cities in the United States and the responsibility to connect these cities with air routes. Now from the point of the view of the traveler, he would like to be able to get on a plane in any city and fly non-stop to any other city of his choice. We see that this is an extreme condition requiring every city in the U. S. to be connected to every other city. In practice, however, this is usually not done. We see that only the major cities in the United States are connected by non-stop routes. If a traveler lives in a smaller city near a major city, what he usually does is go to the major city and then fly non-stop to another major city. The question is, how would you optimize a net of transportation links between these two extremes of connecting every two cities and a system of trunk lines and feeder lines that now operate. What are the parameters involved? What am I trying to optimize? In other words, take the problem that you have the responsibility to select air transporation networks for the United States. You could take the point of view that you wanted to select a system that would serve the country best in case of emergencies or you could say that you wanted a system that would be the most economical or some trade-off between these two. The question is how do you formulate such a problem. In summary then, we find that nature presents many examples of hierarchical structures and that hierarchical structures have some common properties that are independent of content. Later we will go into differences between horizontal relations among elements of a level, and vertical relations among levels. Again the purpose of introducing levels is that they simplify our understanding and description of structures. If there exists common properties among hierarchical structures, this suggests there may exist principles responsible for the hierarchical structures that underly the hierarchies we observe. This commonality of an underlying principle of hierarchical arrangement is not evident in our present laws of physics. The only thing that is so general is the second law of thermodynamics. However, the second law does not seem to apply to morphogenesis. Therefore we feel we must seek new principles or new ways of abstracting, or at least a theory for abstracting something more basic.

VI Atomic-Cosmic Relations

20 March 1969

We now turn to the subject of atomic-cosmic relations as an example of a holistic approach to ordering experience. We are focusing here on the relations in physical systems, not the entities, such as atoms, molecules, crystals, planets, stars, and galaxies. The reason for this subject comes from our own conviction that it is fruitful to examine the subject matter outside one's own specialty. It is also fruitful to examine several subject areas simultaneously. So far, there has been so little progress in looking directly at social phenomena or ESP phenomena, or even transportation phenomena, for that matter, that it may be more fruitful to look at other subjects first. By little progress, we mean that we have not even been able to formulate hypotheses to explain these phenomena, and rather than approach these head-on, it may be useful to look at other areas. One area common to the three I have just mentioned is time. Today's material presents suggestions that might lead to alternate concepts of space and time. This material has implications for alternate concepts of space and time.

And speaking of implications of the material, for our amplification period later, I would like to suggest that we encounter this material in terms of its implications. Can we enter a dialog on what attitudes would result or change if we had different concepts of space or time? In previous seminars we focused on epistemology and its implications. In the next two seminars we might try to formulate what is implied. If the universe, for example, is oscillating rather than if it had a single beginning, such as the big bang theory or the Genesis story, one implication would be, if this is true, (as the Hindu cosmology already claims) we in the West might be more inclined to be open to what eastern religions and people have to say about other things — things other than cosmology.

Today's material may also be a good exercise in trying to consider implications because it is not obvious that we can respond in a typical western way of how to apply it, such as how can we use this information to go faster, or make a new vehicle, or make a profit. Rather, if there are relations between the atomic and cosmic levels, what happens to our attitudes of the relations between humans. Or, what happens to our feeling of alienation, etc. In short, we want to direct your attention to questioning this material in terms of its total implication; not to pigeonhole atomic cosmic matter as science, or something separate from life, or our value for life. The Greeks, in their time, sifted and weighed every drop of knowledge in terms of its implication for all aspects of life. Today, when we consider the glut of information that has been generated since the scientific renaissance, we can appreciate that we are about three centuries behind in sifting and weighing. In case you feel it is unfair to have to work on this horrendous backlog, I can only say that here is one area where there is no expert to call in to do it for us. We are on our own.

This is a specialized subject and it is not being actively researched today. There are probably two reasons for this: one is that most scientific problems are usually picked on the basis of their ability to be solved. The second is just the opposite of this: that if there were success in establishing atomic-cosmic relations, it would probably vitiate many of our currently accepted theories. In any event, it gives us a challenge to try a holistic approach.

Cosmic atomic relationships first came up in some work of Eddington's in the twenties when he became attracted to certain combinations of the fundamental constants of physics that could be put together in dimensionless form. These numbers had some very interesting properties which no one could account for. Several first rate physicists have looked at these number and their possible implications, Schroedinger, Durac, Chandrasekhar, Gutari, and most recently, Gamow. They have all contributed to the literature, which isn't a big literature, on these relationships. In fact, Gamow's last paper, sent off to the Proceedings of National Academy of Science a few days before he died, was on some implications of these cosmic numbers. Now at the present time there does not exist any theoretical connection, any known theory of connection, between microphysics, physics of the atomic structure and the atomic nucleus, and large scale physics of gravitation. But there are a good many clues that there are connections between these, and if there are connections, certainly it would require a revision of a great many of our ideas about the universe and how it is put together. One of the most interesting of these connections has recently been pointed out by Sandage. He points out that we have now have three quite distinct ways of measuring what you might call the "age of the universe"; using that term loosely. One of the meanings of the age of the universe is: the age of formation, time back to the time of formation of the heavy elements. Another meaning of this term is the age of the oldest stars since they were formed, presumably condensed into position on the main sequence. Third, time measured since the universe began to expand from the big bang or the highly condensed state. It turns out that the methods of determining these times are quite distinct but they all come up essentially with the same answer. This is a very striking coincidence. Very briefly, if we want to get the age of the elements we can do this by comparing the number of, say, U235, atoms present, the ratio of that to the number of 238 at the time T, and this is related to the initial abundance ratio of 235 times zero, say, to 238 times zero, times the difference of the rate of decays. These rates, of course, are well known but this is not known. Byer, Burbidge, and Burbidge have worked out a value for this on the manner in which heavy nuclei are constructed and they give 1.65 as that ratio and with that value and the present value of the ratio .00723 which can be accurately measured, they say that the age of the formation of these elements, if they were formed at one time, is 6.6 x 10^9 years. If they were not formed at the same time there is a slight modification and the initial ratio of that is not a critical one, you can change from one to two without changing the age more than, say, between 6.3 and 6.9 x 10^9. It isn't very sensitive to that.

Recently it has been suggested and it is now being adopted, 10^9 years is being called an aeon. So 6.6 aeons is the value of the age if we determine it from radio activity in this way. Now they have another plot that has been developed partly observationally and partly theoretically and this is the plot of stellar evolution. This is the famous HR diagram where this is the luminosity or magnitude of a star and this is its color or temperature, and most stars lie along the so-called main sequence. If we look at certain star clusters, we find the main sequence stars are usually accompanied by giant stars which are located over here in the diagram. In this work, which is due mostly to Sandage, note the clock, that the heaviest and brightest stars leave the main sequence first and move off. Now if it is a young cluster only the very brightest ones have moved off the main sequence to the right. In an older cluster, some of the fainter stars have moved off and the older the cluster, the further down the main sequence we find an absence of stars for they have moved off to _______________region. If we had a clock, this would be one time, and another, etc., and the further down this point of cut-off from the main sequence, the older the cluster.

When we look at the oldest stars, the time is 1.5×10^{10} years or 15 aeons.

The third method for determining the age of the universe is the method for determining the Hubble parameter which is called the expanding universe method. This has to do with determining the time since all the objects were in a very dense core. The farther out galaxies are, the faster they move. This is measured by plotting the observed values for redshifts and magnitudes for objects and calibrating this linear function with distance. The time derived in this method is 10 aeons.

So these results are very suggestive. Some of these results are astronomical observations and some are laboratory measures, others are a combination of the two and partly on a computer in the case of stellar evolution. The consistency within each method is not in question, however, there is no known relation that bridges one method to the other. The fact that three independent methods result in essentially the same age of the universe suggests that the radioactive or atomic levels are in some way or another related to the cosmic levels. Another way of saying this is that atomic clocks and cosmic clocks are related. Whether or not we can go as far as Newton and assert that there is just <u>one</u> clock that governs everything, we don't yet know. But apparently these clocks are related. At least the error is small when we compare each of their time records for the age of the universe — that is, approximately 10 aeons. They each give essentially the same time since some single event, the event here being the origin of the universe.

We should perhaps note in passing that what we take to be essentially the same value, that is

Radioactivity methods: t ∿ 6.6×10^9 years
Stellar Evolution method: t ∿ 1.5×10^{10} years
Hubble Time method: t ∿ 10^{10} years

is within astronomical observational accuracy. The discrepancy between these values can be explained in many ways. The point for us here is that to come up with a value that is approximately 10^9 or 10^{16} seconds from three independent sources is remarkable.

A second area that suggests relations between the atomic and cosmic levels is illustrated in the constants of physics. Almost everything can be reduced to these.

The basic constants of physics with their dimension are summarized below. The macro constants are $\bar{\rho}$ the mean density of the universe, and H, the so-called Hubble time. The micro constants are m_ρ, the mass of the proton, m_e, the mass of the electron, e, the charge on the electron, and $\hbar$, Planck's constant of action. The two meso constants are G, the gravitational constant and c, the velocity of light.

MACRO	MESO	MICRO
$\bar{\rho}$ $\left[\frac{M}{L^3}\right]$	G $\left[\frac{L^3}{MT^2}\right]$	m_ρ $\left[M\right]$
H $\left[\frac{1}{T}\right]$	c $\left[\frac{L}{T}\right]$	m_e $\left[M\right]$
		e $\left[\frac{L}{T}\sqrt{ML}\right]$
		$\hbar$ $\left[\frac{ML^2}{T}\right]$

By taking these constants in various combinations, we are able to derive certain dimensionless quantities, that is, M's, L's, and T's cancel out. The interesting fact is that from these dimensionless constants, we can begin to "structure" the whole universe. This is work that has intrigued several scientists from time to time. The whys are not known, but they work.

The three most important dimensionless quantities that you can derive from atomic constants are:

1) The fine structure constant, $\alpha = \frac{2\pi e^2}{hc} = 137.0377$

2) The ratio of electric to gravitational forces,

$$S = \frac{e^2}{Gm_\rho m_e} = 10^{39.356}$$

3) The ratio of mass of proton to mass of electron, u =

$$u = \frac{m_\rho}{m_e} = 1836.12$$

I think that this last one, $u = 6\pi^5$. Now, these particular values show up in places other than the laboratory. I'll just mention one other thing here. We've listed electrical and gravitational forces. Two other forces are known: weak interactions which are the forces that bind nucleus particles like photons or protons and the strong interactions which bind the nucleus. There are some fundamental constants of these such as the basic energy of proton-proton binding and the Fermi constant of weak interaction, but these are not known with precision and there is some evidence that they can be expressed in terms of these. But this is a set of physics that hasn't been well developed as yet. The constants we are here discussing derive from work over the past 40 or so years and all these values except for G are known to six, and in some cases, seven or eight significant figures.

If we take a velocity times a time, we get a distance. So if we write $T = \frac{1}{H}$ using the Hubble time, cT is a distance which we can think of as the radius of the universe. If we divide cT by the radius of an electron, r_e, which can be derived from these fundamental constants, then:

$$\frac{cT}{r_e} = S$$

where r_e is the radius of the electron or the range of nuclear forces.

$$r_e = e^2/m_e c^2 \text{ by definition.}$$

Another combination is to take the mean density of the universe, $\bar{\rho}$ and multiply it by the radius cubed (that's a valume x density which is equivalent to a mass). We normalize that with respect to the mass of the proton and:

$$\frac{\bar{\rho}(cT)^3}{m} = S^2 \sim 10^{78}$$

Eddington claimed that S^2 or 10^{78} was the number of heavy particles in the universe.

If we compute by observation and theory the gravitational potential of cosmic bodies, that is, the mass of a body divided by its radius, for the largest known entities of each level we find the following:

Star = $10^{38.8} = S$
Galaxy = $10^{39.1} = S$
Cluster = $10^{39.0} = S$
2nd order cluster = $10^{38.7} = S$

where mass is expressed in terms of the mass of the proton and radius is expressed in terms of the Bohr radius, that is,

$a_o = r_e/\alpha^2$.

So let us assume that:

$$\frac{M/m_\rho}{R/a_o} = \sigma S \tag{1}$$

where σ is an unknown number but of the order of unity. We can then write (1) as:

$$\frac{M}{R} = \sigma \frac{m_\rho}{a_o} \cdot \frac{e^2}{Gm_\rho m_e}$$

where M is the mass of an entity in any level from star to second order cluster and R is the radius of any one entity and we substitute for m_ρ. Rearranging, we find:

$$\frac{GM}{c^2R} = \sigma\alpha^2 \tag{2}$$

and this holds for stars, galaxies, clusters and second order clusters. Now from general relativety, Schwarzschild has shown:

$$\frac{GM}{c^2R} < \frac{1}{2} \tag{3}$$

When we look at the observations, we find the observed limit (2) is less than the Schwarzschild limit (3). These are shown schematically in Figure (1), Gravitational Potentials of Cosmic Bodies. The point here is that these observed potentials of cosmic bodies imply relations between the atomic and cosmic levels.

One other place that S appears in a quite unexpected way is in the Bohr model of an atom. The velocity of an electron in the first unexcited orbit is αc, about 3000 km/sec. The radius is a_o, so the distance divided by the velocity gives the time it takes for the electron to make one orbit. If we call this T_e, the time of one electron period then:

$$T_e = \frac{2\pi a_o}{\alpha c} = 10^{-15.818} \text{ seconds}$$

Now there's another time associated with all gravitating objects called the Schuster time, T_H. In the case of the hydrogen atom,

$$T_H = \frac{2\pi a_o{}^{3/2}}{\sqrt{Gm_\rho}} .$$

The Schuster time in the case of the earth is time it takes a satellite to orbit the earth at its surface, this is approximately 84 minutes. For the sun, the Schuster time is close to two hours. This is an extremely important relation and it can be written in a slightly different form:

$$T_H = \sqrt{\frac{3\pi}{G\rho}}$$

where $\overline{\rho}$ is the mean radius of the object. This Schuster time connects density to time in all gravitating bodies. The denser, the shorter this characteristic Schuster time. If we compute T_H for a hydrogen atom:

$$T_H = 10^{3.85860}$$

and

$$\frac{T_H}{T_e} = \sqrt{S}$$

So again we see the dimensionless constant, S, appears.

We'll take one more result, due to Chandrasekhar, and then we'll build a universe. Chandrasekhar showed the masses of different objects could be related to the fundamental constants,h, c, G, m_ρ by a relation of the following type:

$$M_2 = \frac{\hbar c}{G}^{\upsilon} \frac{1}{m_\rho^{2\upsilon-1}}$$

where for stars, $\upsilon = 3/2$. This result was derived astrophysically. He then observed that if $\upsilon = 7/4$, he obtained the mass of a galaxy but this doesn't make sense astrophysically. That is you cannot derive this result using astrophysical laws. However, we note that if we take $\upsilon = 2$, we obtain $M = S^2$ or the mass of the universe. The basis of the derivation for stars is for polytrops of the order 3.

Now if we put all these bits and pieces together, we see they fit. We will make a cosmic diagram (Figure 2) in the following way. The abcissa in the log of Mass and the ordinate in the log of Rochus. We note that the hydrogen atom sits at the lower left hand corner of the diagram and the universe sits at the upper right hand corner of the diagram.

The mass is S^2 times m_ρ. Everything in the horizontal direction must be multiplied by m_ρ, the mass of the proton and since the radius is S times a_o, everything in the vertical direction must be multiplied by a_o, the radius of the Bohr atom.

The observed potential limit, the α^2 limit cuts diagonally across the diagram from mass = S^1 to radius = S^2. The Schwarzschild limit is parallel, a little to the right and according to the theory of relativity, the area below this limit is totally excluded. According to observation, the area between the two diagonal potential limits is also an excluded region. All the bodies that are observed to exist in the universe are found to the left of the observed potential limit line.

We now note that all physical entities in the universe from the hydrogen atom up to the level of stars lie along a line that cuts from the lower left hand corner of the diagram and intersects the observed potential limit at mass $=S^{3/2}$. That is, asteroids, satellites, planets up to the level of stars lie along this band. (It's really a band, not a line, since density variations are on the order of ________). Parallel to this line is another line intersecting the potential limit diagonal at mass = $S^{7/4}$ on which we find all the stars. Finally a third parallel line that intersects the potential limit diagonal at mass = $S^{15/8}$ is a line containing all the galaxies, clusters of galaxies, and so on.

That there should be so much regularity as seen in this cosmic diagram and the fact that we cannot account for this astrophysically presents a challenge. The question is: where do we go from here? How can one take this kind of evidence and begin to make a postulatory or axiomatic system? The following table shows the actual values calculated for the cosmic diagram. We note that for each level, the fit between the observed values and the values derived from the cosmic diagram model is better than astronomical accuracy.

	PLANETS	STARS	GLOBULAR CLUSTERS	GALAXIES	GALAXY CLUSTERS
MAXIMUM					
OBSERVED	JUPITER	VVCEPHEIA	M22	M87	LOCAL
	30.279	35.225	40.14	45.9	48.3
MODEL	30.338	35.258	40.18	45.1	48.4
	$\upsilon = 11$	$\upsilon = 12$	$\upsilon = 13$	$\upsilon = 14$	$\upsilon = 11/6$
MINIMUM					
OBSERVED	MERCURY	RCMaB	M5	N~~M~~GC6822	U.M.I.
	26.509	32.340	37.3	41.9	46.6
MODEL	26.782	31.702	36.6	41.5	46.5

Log_{10} grams

This remarkable correspondence suggests that the relations suggested by these dimensionless constants in nature could be generalized. If we could think scale-wise, that is, replace atoms with stars, the data from observational astronomy could be generalized in this manner. This would be one way that would afford a way to go from level to level in hierarchical structures. In other words, we could make the proper substitutions in making the proper modeling to include all the levels of physical entities observed.

VII: Rhythms, Clocks and Time

27 March 1969

In introduction, there are three things to mention this evening. First, we want to remind ourselves about the amplification method of the seminar; second, we want to point out the new series that we plan to go into in May; and last, we had perhaps best review the last four sessions of this second series.

In our attempt to find new methods of synthesis, we feel that we must also find a new seminar technique that supports the goal of these seminars. Our thesis is that there are two phases in the cybernetic age in which we now live. One is the reductionist aspect which tries to understand and use control systems in industrial, educational, and governmental processes; and the other is the holistic aspect which tries to restore ecological balances to industrial, educational, and governmental processes. The holistic approach focuses on environment and on context. Our seminar technique requires that we develop an attitude of attentive listening and tentative adoption. By that, we mean to try to encourage each other to really listen to what is being said and adopt it, for the moment -- not to categorize it nor to dismiss it. The amplification that we are trying to learn how to do means that one tries to locate the implications in the material being presented. This is a rather difficult thing to do because we don't often see the implications of new ideas until much later and sometimes too late to be able to see if we want to adopt them. So amplification has to do with encountering the material and listening for implications.

The new series that we want to go into next month turns to phenomena studied by the social sciences. In contrast to physical sciences, the concept of research in social phenomena is not well defined. Some of the difficulties contributing to this lack of precision are that well formulated theories do not yet exist, also the study of humans differs from the study of physical entities in that our aim must not be manipulation. Another difference is that the results or products of our research efforts to study social phenomena are quite different from the products that result from research in physical science. For example, in physical science we can define a research product in the form of something like a spectra. In social science a product might be as tenuous as the introduction of a new process or a mode of operation in an organization or community. A fourth difference between the two has to do with the complexity and feedback responsiveness of social systems. These at times vitiate the validity of experimental and simulation techniques. The only meaningful and desirable social experiments are in the real world. In lieu of these differences we hope to suggest some new directions in the series that we take up next month.

In review of the series on atomic-cosmic relations that we have just finished, we need to say again that this material provides clues to alternate approaches in other areas. The first lecture on the problem of levels had to do with the fact of the multi-level structure of reality. Factual science does not prove the existence of the external world but it definitely presupposes this thesis as a hypothesis. Reality then is not a solid homogeneous block. It is divided into levels. Each is characterized by a set of properties and laws of its own. Higher levels are rooted in lower levels, both historically and contemporaneously. They have emerged in the course of time from the lower levels in a number of evolutionary processes. We considered examples of level structure that included the number system, the abstract, concrete, or sign-symbol axis. We considered biological systems that contain levels of system activity. We looked at physical systems that include levels of material entities, from particles, atoms, crystals, up to galaxies, and the universe itself. There is the example of the level structure of knowledge. Social aggregates display levels in numerous examples. We looked at the levels of language in computers, such as machine language, assembly language, and procedural language. Also in computers memories are arranged in levels and problem solving strategies or techniques are arranged in levels. Another example of levels is illustrated by a level structure in information, one level being classificational, a second being relational, and a third being relevantial. In all of these levels, there are various basic questions. Some of the structures containing these level contents are trees and some are semi-lattices. We remember, we note, that tree structures exclude the possibility of overlapping sets and therefore, are much more restrictive. We also ask the question, are levels imposed or intrinsic, and there we discussed the differences between Gaussian distributions versus Zipf's harmonic law distributions. That is, we asked are entities such as galaxies possible for any number of stars. If it is a Gaussian distribution, it seems that the answer to this is no and therefore, the implication is that Gaussian distributions imply intrinsic levels.

In another seminar entitled, "Hierarchies and Polyarchies," we considered various definitions of a hierarchy. We note that the use of the word hierarchy to represent a set of related levels is more general than the frequently employed usage in which the relation between levels is specified as that of control or dominance. We also pointed out the advantages of modularity. Modularity allows sufficient time to evolve complexity. This notion is illustrated in the two watch makers, Hora and Tempus. Another advantage of modularity is that it allows for subsystems to be repaired or modified without disrupting the whole system. In other words a systems arranged in modules is not as vulnerable as one that is not.

In the third seminar we discussed atomic-cosmic relations. First we noted that there are three methods used to determine the age of the universe. All three are distinct methods and all three give the same answer within observational error. We then turned to the constants of nature. We looked at three levels of constants, the cosmic constant which has to do with the macro universe as a whole, the nuclear or mezzo constants which have to do with intermediate scales, and the atomic or micro constants. We found relations, both historically from Eddington and Haas, and showed observations lead to additional parameters expressing the constants of S, α, and μ. We now turn to the evening's topic, Rhythms, Clocks, and Time.

I might reemphasize the last point. We do want to emphasize the holistic view by focusing on relations, not entities. We try to look at wholes, not parts. This of course means we have to abandon certain points of view of classical physics. For example, we cannot use the methods of astrophysics as the guiding tool in studying the universe because astrophysics is laboratory physics. If we try to explain all phenomena in terms of terrestrial laboratory physics, we are not really focusing on relations between entities we can't bring into the laboratory.

The first place we have tried out this holistic approach then is in looking at the universe as a whole. This is also because I'm an astronomer and this subject is most familiar to me personally. Whether we can find guiding principles from this applied to the specific of cosmology remains to be seen. But we need a few specifics to start with and this was an easy one for me to tackle. We hope we can use some of the methods in the specifics of social systems the next time.

What results did we get from looking at the universe holistically? Are the results of interest? We certainly did come up with some startling new results. In the sense of explaining these by classical methods, we get nowhere. But in the sense that they provide relations between various entities they appear valid. There is no way known to perform a statistical test to check some of these relations. I think it would be a challenging problem for statisticians to see if they could formulate tests that bridge phenomena of different levels.

Essentially the result of the Cosmic Diagram model is that all the observed cosmic bodies in the universe can be located on a Mass-Radius Diagram. This diagram can be generated from one of the dimensionless constants, namely the ratio of the electric or Coulomb forces to the gravitational forces. Some overlay results that come from the Cosmic Diagram Model are that mass bounds -- upper and lower limits -- of all the known or observed bodies can be derived in terms of these fundamental frequencies, powers of S. This suggests that the cosmic bodies -- these structures and substructures -- come into existence through some resonance phenomena. We are really talking about various frequencies and these resonate. Some are harmonies of each other. The different levels, stars, clusters, galaxies, and so on, when represented as a series of harmonies, numberically fit. You may ask what's vibrating? This is a physical question and this is what we must now try to answer.

I want to continue to look at these various harmonies. I want to look at the various cycles that we are familiar with and show here relations between these cycles. We will start by reviewing some of the cosmic cycles and then we will turn to some biological cycles. Finally we will look at what may be a common source for both biological cycles and rhythms and cosmic cycles and rhythms. We will find that certain correlation that have been suggested between these two levels may have a valid basis.

First, let me review briefly from the Cosmic Diagram the notion of the basic unit of time associated with the hydrogen atom. If

$$\tau_o = \frac{2\pi a_o^{3/2}}{\sqrt{Gmp}}$$

where a_o is the radius of the Bohr atom and mp is the mass of the bar~~ium~~yon, then

$$\log_{10}\tau_o = 3.8597.$$

We will take τ_o as the basic unit of time and list the characteristic time of each of the observed bodies in the universe in terms of the dimensionless constant S.

Universe:	$S^{1/2}\tau_o$	10^{16} years
2° cluster:	$S^{3/8}\tau_o$	$10^{10.84}$ years (70-80 eons)
1° cluster:	$S^{1/3}\tau_o$	
Galaxies:	$S^{1/4}\tau_o$	
Small galaxies:	$S^{1/6}\tau_o$	
Quasars:	$S^{1/8}\tau_o$	
Stars:	$S^{o}\tau_o$	
Pulsars:	$S^{-1/8}\tau_o$	
	$S^{-1/16}\tau_o$	

The first entry, 10^{16} years doesn't sound like anything we've heard in cosmology for thirty years. But back in the 30's there were debates between what we called the long time scale and the short time scale of the universe. The short time scale was of the order of a couple of eons -- 2 - 4 x 10^9. The long time scale involved the relaxation time of clusters and it had to be of the order of 10^{15} or 10^{16} years. We remember from last time it was felt the age of the universe is about ten eons, i.e., 6.9 to 1.5 x 10^9 years.

The second order clusters are about $10^{10.84}$ years. This is similar to the Hubble time but it very nearly is the total oscillating time of the universe. That is, if the universe oscillates, it stars expanding, then collapses on itself again, has rebirth, and continues cycle after cycle, then this interval is in the neighborhood of 80 eons. But it may be that our observations that lead us to this are really representing a substructure of the universe and not the total structure. The values used to determine the Hubble time are those of second order clusters, so I'm proposing that the universe that Sandage is talking about is the second order cluster universe whose characteristic time is $S^{3/8}\tau_o$, not the universe of time $S^{1/2}\tau_o$.

We can come down to the first order clusters whose time is $10^{6.8}$ years which is an earlier value of Hubble time. Small galaxies have a characteristic time of $10^{2.9}$ years or 834 years. If we continue down through this list, we come to $S^{1/8}\tau_o$ which is 19.05 years. For various reasons I suspect that writing the word, *quasar*, in this place may turn out to be correct. At stars we have $S^o\tau_o$ or $2^h0^m39^5.37$. If we go further, we find that the characteristic time of $S^{-1/8}\tau_o$ is of the order of 1/10 sec. We might write the word *pulsar* in there, and finally, $S^{-1/6}\tau_o$ which is about a millisecond. Below this we run into the cutoff of nuclear density. (All these given are less dense than the nucleus.) If such bodies exist in abundance, this lowest level would be densities of the order of the moon $\sim 10^{28}$ gms.

5·8-6

Metataxis Seminar

Data Display

May 8, 1969

The primary purpose of our seminars on Metataxis is to detect and establish relations, laws, and principles. These are the basic economies of thought. They are keys to understanding and they are the framework for human meaning. Our seminars are intended to explore the various pathways that lead us to the awareness of relationship.

One of the most important pathways is through measurement. To discover a relation we get data and display it in various ways. Frequently after acquiring a great deal of data and no relation, either of a regression sort, a correlation, or a functional relation appears, then our answer is always to get more data. In fact, "get more data" has become a cliche. It has become one of our cliches for how to solve all problems, such as "back to the drawing boards;" "there ought to be a law," or "write a check." In fact data acquisition has become an end in itself. Many scientists and engineers have lost sight of the reasons for collecting data and have made data acquisition a fetish.

Many times especially in the soft disciplines where hard data are traditionally difficult to come by, scientists allow themselves to be more impressed by numerical data and the results of measurement than they are by theories or structures which are the primary purpose of the collection of data. The primary purpose of science is the reconstruction of pattern or the building of an isomorphic map in our constructs of propositions, laws and principles to the real world. This is our task in social phenomena as well.

Today we are going to talk about various pathways to relation and structure, and certainly measurement is one of these pathways. But we are not going to emphasize collection of data, but rather, its display. We find many relations lie undetected in data that has already been accumulated. For example, in previous seminars we discussed the α^2 potential bound, which has been concealed in published literature for at least two decades. Now the more direct pathway to relation is through classification and I would like to draw a diagram on the board and dwell briefly on the epistomology of classification. Classification is a first step toward structure, just as order ranking is a first step toward measurement. But classification is an imposed structure. It is not necessarily an intrinsic or ortho structure, but science must begin with classification We have, for example, botany, classification of the various observed plants. But frequently, we fall behind in revising our classification diagrams as real relations are discovered. For example, it has been pointed out that our most basic classification scheme, animal versus vegetable, now needs to be revised in view of ortho relations that have been recently discovered in microbiology. Another example, when vitamins were first discovered, they were classified by the foods in which they occurred. Now that their chemical structure is better understood, it is seen that the original classifications of B complexes, C's, etc., are not the ortho structure for vitamins.

Measurement is primarily nothing more than a set of rules for assigning a numeral to some aspect of entities.

The basic ideas involving measurement were first given to us by John Stewart Mill, who made four distinct classes of measurement. The first he called nominal. A nominal measurement recognizes that entities are different. A name may be given to the different entities that are differentiated and in this sense, nominal measurement and classification are closely related. Following this first rough form of measurement, we come to rank order, which means that an ordering measurement can be assigned to the entities. Third we come to interval measurement through differences and through ratios. It is these two types of interval measurement that lead to the concepts of scale and zero point. Finally, we have composite measurements which combine two or more independent sets as in complex numbers and vectors.

Now in addition to the measurement branch of the tree, we have the structure branch of the tree and it is here that we have as primary classification and then through the operations of display we hope to be lead ultimately to ortho structure which is making visible the fundamental principles, laws and relations that exist in our organization and structure.

Amplification Technique

13 March 1969

When you look historically at the different formats by which people come together to communicate, the principal one we are familiar with is the didactic form; when the professor gets up and lectures and then the pupils give him back his stuff on the exams, which is one way we are supposed to not only learn it and repeat, but absorb it. adopt it. There is the same format in the church -- you go to the sermon, but instead of following with an exam, they postpone that until the final judgment, I guess. In my opinion the most successful method is where the leader raises questions and sort of deftly guides the people to the points and you follow it. This was named after the Number One expert, Socrates. But this is not used too much anymore. What we do encounter to some extent is the method of the Royal Society which is really a game. This is a game which starts with a lecture and ends up with a one-upmanship exercise. The way you score it is as follows: the lecturer is trying to be over everybody's head and if nobody in the end can ask an intelligent question, the lecturer wins. But if somebody can get up and raise an intelligent question, then it is a draw. However, if he can show the lecturer is bluffing, is giving a snow job and he can demonstrate this, then the lecturer not only loses, but he has lost the war and the audience wins. That is the game they really play. I have been around a lot of the meetingsof the Royal Society, the Royal Astronomical Society, and they really play this game.

Then we have the format more recently of the sensitivity and encounter groups which are built around the question of how do you feel about this. Their questions are supposed to be on how do you feel about it now. Then there is psychotherapy format which is a sort of personal relation between patient and physician. Then there is the old bull session, free association, and then you go to a more sophisticated version of this, such as the RAND Corporation's brain storming sessions, in which you hope that through free association there will be some useful fallout. Then there are the formats of the courts of law and debating societies where the emphasis is as much on how you present the material as it is on the material itself; in fact, it is more, and on personality.

We want to introduce something a bit different from all of these concepts. We call it the amplification format. The process here is not to encounter each other, as in a sensitivity group, but to encounter certain material and to code it off, to work together, to synthesize, to see if we can actually turn a group into a creative organism. There are some rules about how this amplification actually works: you will have one person present some material for a few moments, called the core material, and then you can have one diagram this core material, and one speaker may want to take it off to suggest something here to him, and develop it out this way; and another one may want to develop it in some other direction, etc. The idea is you begin with the core material and amplify it and develop it in some way, but not to free associate for this suggests some kind of motive. You have to build bridges. There should be a presenter for material, to communicate core material and then there will be a second person, a monitor, we will call him the "Lord Protector of Focus," a Cromwellian concept here. He is supposed to keep the intention, to keep the dialog focussed on the material -- not to chop it off if it is going in a fruitful direction, but not to let it wander all over. The participants have the responsibility to encounter the material and amplify this. To do this, we have to listen to each other.

Everyone is supposed to listen to everyone else and you should assume that everything that is being said is considered tentatively adopted, if you possibly can. Is this true, I really don't believe it, but let's say this is true -- what does it mean? Just hold for a few minutes some idea that may be wild as true, and give it a day in court, so to speak. Then expand it, if you can, giving examples to confirm it, or refute it with examples that modify it, or really the most important in my opinion is what new questions it suggests. We use a kind of departure from the KETTHORN (?) idea here, when the material is presented for a few minutes, then we discuss it, and while the material is being presented, it is much better that there be no discussion except perhaps a question for clarification until we get to the discussion period. We haven't been adhering to that and I think we indulge in too much rambling. If we were to have rules for the amplification method, they would look something like this: no rejection without refutation. If you reject something, you should say I reject this because it contradicts this or this, or it doesn't make sense, or whatever, give the reason. No dialogs. No ~~items~~ islands in the sense here -- bridges must be supplied anytime you want to make modification. Another thing I want to do is get away from dogmatism and authoritarianism of all sorts. We know that Aristotle is gone and everybody on the books is rated from the age of ? authoritarianism but we still have our favorite Nobel prize winners and they have in some way taken the place of Aristotle for us. We may seem quite uncertain, and uncertainty in our culture is a weakness and we have seen some politics where a man like McCarthy/or Stevenson does not appeal to the electorate because he says I don't have the answers, and we are going to find some answers; while the other fellow says I have the answers and he is going to get elected because in our culture it is an equation between this feeling of certainty and dogmatism. We want to avoid free association. How do I know what I think until I hear what I am going to say? Avoid that because this is not a T group and it is not a jousting experiment for our egos. So basically, we want to listen to each other, we want to search for new ideas, and we want to build bridges. This is the outcome of all these other formats. We have not perfected this, we come together not just to exchange ideas but to try to create an organism here of joint _____________ and we hope to some day figure out how to do this.

Atomic-Cosmic Relations

20 MARCH 1969

We now turn to the subject of atomic-cosmic relations as an example of a holistic approach to ordering experience. We are focusing here on the relations in physical systems, not the entities, such as atoms, molecules, crystals, planets, stars, and galaxies. The reason for this subject comes from our own conviction that it is fruitful to examine the subject matter outside one's own specialty. It is also fruitful to examine several subject areas simultaneously. So far, there has been so little progress in looking directly at social phenomena or ESP phenomena, or even transportation phenomena, for that matter, that it may be more fruitful to look at other subjects first. By little progress, we mean that we have not even been able to formulate hypotheses to explain these phenomena, and rather than approach these head-on, it may be useful to look at other areas. One area common to the three I have just mentioned is time. Today's material presents suggestions that might lead to alternate concepts of space and time. This material has implications for alternate concepts of space and time.

And speaking of implications of the material, for our amplification period later, I would like to suggest that we encounter this material in terms of its implications. Can we enter a dialog on what attitudes would result or change if we had different concepts of space or time? In previous seminars we focused on epistemology and its implications. In the next two seminars we might try to formulate what is implied. If the universe, for example, is oscillating rather than if it had a single beginning, such as the big bang theory or the Genesis story. The implication would be, if this is true (as the Hindu cosmology already claims), we in the West might be more inclined to be open to what eastern religions and people have to say about other things — things other than cosmology.

Today's material may also be a good exercise in trying to consider implications because it is not obvious that we can respond in a typical western way of how to apply it, such as how can we use this information to go faster, or make a new vehicle, or make a profit. Rather, if there are relations between the atomic and cosmic levels, what happens to our attitudes of the relations between humans. Or, what happens to our feeling of alienation, etc. In short, we want to direct your attention to questioning this material in terms of its total implication; not to pigeonhole atomic cosmic matter as science, or something separate from life, or our value for life. The Greeks, in their time, sifted and weighed every drop of knowledge in terms of its implication for all aspects of life. Today, when we consider the glut of information that has been generated since the scientific renaissance, we can appreciate that we are about three centuries behind in sifting and weighing. In case you feel it is unfair to have to work on this horrendous backlog, I can only say that here is one area where there is no expert to call in to do it for us. We are on our own.

This is a specialized subject and it is not being actively researched today. There are probably two reasons for this: one is that most scientific problems are usually picked on the basis of their ability to be solved. The second is just the opposite of this: that if there were success in establishing atomic-cosmic relations, it would probably vitiate many of our currently accepted theories. In any event, it gives us a challenge to try a holistic approach.

Cosmic atomic relationships first came up in some work of Eddington's in the twenties when he became attracted to certain combinations of the fundamental constants of physics that could be put together in dimensionless form. These numbers had some very interesting properties which no one could account for. Several first rate physicists have looked at these number and their possible implications, Schroedinger, Durac, Chandrasekhar, ~~Gutari~~ Kotari, and most recently, Gamow. They have all contributed to the literature, which isn't a big literature, on these relationships. In fact, Gamow's last paper, sent off to the Proceedings of National Academy of Science a few days before he died, was on some implications of these cosmic numbers. Now at the present time there does not exist any theoretical connection, any known theory of connection, between microphysics, physics of the atomic structure and the atomic nucleus, and large scale physics of gravitation. But there are a good many clues that there are connections between these, and if there are connections, certainly it would require a revision of a great many of our ideas about the universe and how it is put together. One of the most interesting of these connections has recently been pointed out by Sandage. He points out that we have now have three quite distinct ways of measuring what you might call the "age of the universe" using that term loosely. One of the meanings of the age of the universe is: the age of formation, time back to the time of formation of the heavy elements. Another meaning of this term is the age of the oldest stars since they were formed, presumably condensed into position on the main sequence. Third, time measured since the universe began to expand from the big bang or the highly condensed state. It turns out that the methods of determining these times are quite distinct but they all come up essentially with the same answer. This is a very striking coincidence. Very briefly, if we want to get the age of the elements we can do this by comparing the number of, say, U235, atoms present, the ratio of that to the number of U238 at the time T, and this is related to the initial abundance ratio of 235 at time~~s~~ zero, say, to 238 at time~~s~~ zero, times the difference of the rate of decays. These rates, of course, are well known but this is not known. Byer, Burbidge, and Burbidge have worked out a value for this on the manner in which heavy nuclei are constructed and they give 1.65 as that ratio and with that value and the present value of the ratio .00723 which can be accurately measured, they say that the age of the formation of these elements, if they were formed at one time, is 6.6 x 10^9 years. If they were not formed at the same time there is a slight modification and the initial ratio of that is not a critical one, you can change from one to two without changing the age more than, say, between 6.3 and 6.9 x 10^9. It isn't very sensitive to that.

Recently it has been suggested and it is now being adopted, 10^9 years is being called an aeon. So 6.6 aeons is the value of the age if we determine it from radio activity in this way. Now they have another plot that has been developed partly observationally and partly theoretically and this is the plot of stellar evolution. This is the famous HR diagram where this is the luminosity or magnitude of a star and this is its color or temperature, and most stars lie along the so-called main sequence. If we look at certain star clusters, we find the main sequence stars are usually accompanied by giant stars which are located over here in the diagram. In this work, which is due mostly to Sandage, note the clock, that the heaviest and brightest stars leave the main sequence first and move off. Now if it is a young cluster only the very brightest ones have moved off the main sequence to the right. In an older cluster, some of the fainter stars have moved off and the older the cluster, the further down the main sequence we find an absence of stars for they have moved off to the giant region. If we had a clock, this would be one time, and another, etc., and the further down this point of cut-off from the main sequence, the older the cluster.

When we look at the oldest stars, the time is 1.5 x 10^{10} years or 15 aeons.

The third method for determining the age of the universe is the method for determining the Hubble parameter which is called the expanding universe method. This has to do with determining the time since all the objects were in a very dense core. The farther out galaxies are, the faster they move. This is measured by plotting the observed values for redshifts and magnitudes for objects and calibrating this linear function with distance. The time derived in this method is 10 aeons.

So these results are very suggestive. Some of these results are astronomical observations and some are laboratory measures, others are a combination of the two and partly on a computer in the case of stellar evolution. The consistency within each method is not in question, however, there is no known relation that bridges one method to the other. The fact that three independent methods result in essentially the same age of the universe suggests that the radioactive or atomic levels are in some way or another related to the cosmic levels. Another way of saying this is that atomic clocks and cosmic clocks are related. Whether or not we can go as far as Newton and assert that there is just <u>one</u> clock that governs everything, we don't yet know. But apparently these clocks are related. At least the error is small when we compare each of their time records for the age of the universe — that is, approximately 10 aeons. They each give essentially the same time since some single event, the event here being the origin of the universe.

We should perhaps note in passing that what we take to be essentially the same value, that is

Radioactivity methods: $t \sim 6.6 \times 10^9$ years
Stellar Evolution method: $t \sim 1.5 \times 10^{10}$ years
Hubble Time method: $t \sim 10^{10}$ years

is within astronomical observational accuracy. The discrepancy between these values can be explained in many ways. The point for us here is that to come up with a value that is approximately 10^9 years or 10^{16} seconds from three independent sources is remarkable.

A second area that suggests relations between the atomic and cosmic levels is illustrated in the constants of physics. Almost everything can be reduced to these.

The basic constants of physics with their dimensions are summarized below. The macro constants are $\bar{\rho}$ the mean density of the universe, and H, the so-called Hubble time. The micro constants are m_ρ, the mass of the proton, m_e, the mass of the electron, e, the charge on the electron, and $\hbar$, Planck's constant of action. The two meso constants are G, the gravitational constant and c, the velocity of light.

MACRO	MESO	MICRO
$\bar{\rho}\ \left[\frac{M}{L^3}\right]$	$G\ \left[\frac{L^3}{MT^2}\right]$	$m_\rho\ [M]$
$H\ \left[\frac{1}{T}\right]$	$c\ \left[\frac{L}{T}\right]$	$m_e\ [M]$
		$e\ \left[\frac{L}{T}\sqrt{ML}\right]$
		$\hbar\ \left[\frac{ML^2}{T}\right]$

By taking these constants in various combinations, we are able to derive certain dimensionless quantities, that is, M's, L's, and T's cancel out. The interesting fact is that from these dimensionless constants, we can begin to "structure" the whole universe. This is work that has intrigued several scientists from time to time. The whys are not known, but they work.

The three most important dimensionless quantities that you can derive from atomic constants are:

1) The fine structure constant, $\alpha = \frac{2\pi e^2}{hc} = 137.0377$

2) The ratio of electric to gravitational forces,

$$S = \frac{e^2}{Gm_\rho m_e} = 10^{39.356}$$

3) The ratio of mass of proton to mass of electron,

$$u = \frac{m_\rho}{m_e} = 1836.12$$

I think that this last one, $u = 6\pi^5$. Now, these particular values show up in places other than the laboratory. I'll just mention one other thing here. We've listed electrical and gravitational forces. Two other forces are known: weak interactions which are the forces that bind nucleus particles like photons or protons and the strong interactions which bind the nucleus. There are some fundamental constants of these such as the basic energy of proton-proton binding and the Fermi constant of weak interaction, but these are not known with precision and there is some evidence that they can be expressed in terms of these. But this is a set of physics that hasn't been well developed as yet. The constants we are here discussing derive from work over the past 40 or so years and all these values except for G are known to six, and in some cases, seven or eight significant figures.

If we take a velocity times a time, we get a distance. So if we write $T = \frac{1}{H}$ using the Hubble time, cT is a distance which we can think of as the radius of the universe. If we divide cT by the radius of an electron, r_e, which can be derived from these fundamental constants, then:

$$\frac{cT}{r_e} = S$$

where r_e is the radius of the electron or the range of nuclear forces.

$$r_e = e^2/m_e c^2 \text{ by definition.}$$

Another combination is to take the mean density of the universe, $\overline{\rho}$ and multiply it by the radius cubed (that's a volume x density which is equivalent to a mass). We normalize that with respect to the mass of the proton and:

$$\frac{\overline{\rho}(cT)^3}{m} = S^2 \sim 10^{78}$$

Eddington claimed that S^2 or 10^{78} was the number of heavy particles in the universe.

If we compute by observation and theory the gravitational potential of cosmic bodies, that is, the mass of a body divided by its radius, for the largest known entities of each level we find the following:

Star $= 10^{38.8} = S$

Galaxy $= 10^{39.1} = S$

Cluster $= 10^{39.0} = S$

2nd order cluster $= 10^{38.7} = S$

where mass is expressed in terms of the mass of the proton and radius is expressed in terms of the Bohr radius, that is,

$$a_o = r_e/\alpha^2.$$

So let us assume that:

$$\frac{M/m_\rho}{R/a_o} = \sigma S \tag{1}$$

where σ is an unknown number but of the order of unity. We can then write (1) as:

$$\frac{M}{R} = \sigma \frac{m_\rho}{a_o} \cdot \frac{e^2}{Gm_\rho m_e}$$

where M is the mass of an entity in any level from star to second order cluster and R is the radius of any one entity and we substitute for m_ρ. Rearranging, we find:

$$\frac{GM}{c^2R} = \sigma\alpha^2 \tag{2}$$

and this holds for stars, galaxies, clusters and second order clusters. Now from general relativety, Schwarzschild has shown:

$$\frac{GM}{c^2R} < \frac{1}{2} \tag{3}$$

When we look at the observations, we find the observed limit (2) is less than the Schwarzschild limit (3). These are shown schematically in Figure (1), Gravitational Potentials of Cosmic Bodies. The point here is that these observed potentials of cosmic bodies imply relations between the atomic and cosmic levels.

One other place that S appears in a quite unexpected way is in the Bohr model of an atom. The velocity of an electron in the first unexcited orbit is αc, about 3000 km/sec. The radius is a_o, so the distance divided by the velocity gives the time it takes for the electron to make one orbit. If we call this T_e, the time of one electron period then:

$$T_e = \frac{2\pi a_o}{\alpha c} = 10^{-15.818} \text{ seconds}$$

Now there's another time associated with all gravitating objects called the Schuster time, T_H. In the case of the hydrogen atom,

$$T_H = \frac{2\pi a_o{}^{3/2}}{\sqrt{Gm_\rho}} .$$

The Schuster time in the case of the earth is time it takes a satellite to orbit the earth at its surface, this is approximately 84 minutes. For the sun, the Schuster time is close to two hours. This is an extremely important relation and it can be written in a slightly different form:

$$T_H = \sqrt{\frac{3\pi}{G\bar{\rho}}}$$

where $\overline{\rho}$ is the mean ~~radius~~ density of the object. This Schuster time connects density to time in all gravitating bodies. The denser, the shorter this characteristic Schuster time. If we compute T_H for a hydrogen atom:

$$T_H = 10^{3.85860}$$

and

$$\frac{T_H}{T_e} = \sqrt{S}$$

So again we see the dimensionless constant, S, appears.

We'll take one more result, due to Chandrasekhar, and then we'll build a universe. Chandrasekhar showed the masses of different objects could be related to the fundamental constants,h, c, G, m_ρ by a relation of the following type:

$$M_2 = \frac{hc}{G}^{\upsilon} \frac{1}{m_\rho^{2\upsilon-1}}$$

where for stars, $\upsilon = 3/2$. This result was derived astrophysically. He then observed that if $\upsilon = 7/4$, he obtained the mass of a galaxy but this doesn't make sense astrophysically. That is you cannot derive this result using astrophysical laws. However, we note that if we take $\upsilon = 2$, we obtain $M = S^2$ or the mass of the universe. The basis of the derivation for stars is for polytrops of the order 3.

Now if we put all these bits and pieces together, we see they fit. We will make a cosmic diagram (Figure 2) in the following way. The abcissa in the log of Mass and the ordinate i~~n~~s the log of ~~Rochus~~ Radius. We note that the hydrogen atom sits at the lower left hand corner of the diagram and the universe sits at the upper right hand corner of the diagram.

The mass is S^2 times m_ρ. Everything in the horizontal direction must be multiplied by m_ρ, the mass of the proton and since the radius is S times a_o, everything in the vertical direction must be multiplied by a_o, the radius of the Bohr atom.

The observed potential limit, the α^2 limit cuts diagonally across the diagram from mass = S^1 to radius = S^2. The Schwarzschild limit is parallel, a little to the right and according to the theory of relativity, the area below this limit is totally excluded. According to observation, the area between the two diagonal potential limits is also an excluded region. All the bodies that are observed to exist in the universe are found to the left of the observed potential limit line.

We now note that all physical entities in the universe from the hydrogen atom up to the level of stars lie along a line that cuts from the lower left hand corner of the diagram and intersects the observed potential limit at mass $=S^{3/2}$. That is, asteroids, satellites, planets up to the level of stars lie along this band. (It's really a band, not a line, since density variations are on the order of ________). Parallel to this line is another line intersecting the potential limit diagonal at mass = $S^{7/4}$ on which we find all the stars. Finally a third parallel line that intersects the potential limit diagonal at mass = $S^{15/8}$ is a line containing all the galaxies, clusters of galaxies, and so on.

That there should be so much regularity as seen in this cosmic diagram and the fact that we cannot account for this astrophysically presents a challenge. The question is: where do we go from here? How can one take this kind of evidence and begin to make a postulatory or axiomatic system? The following table shows the actual values calculated for the cosmic diagram. We note that for each level, the fit between the observed values and the values derived from the cosmic diagram model is better than astronomical accuracy.

	PLANETS	STARS	GLOBULAR CLUSTERS	GALAXIES	GALAXY CLUSTERS
MAXIMUM					
OBSERVED	JUPITER	VVCEPHEIA	M22	M87	LOCAL
	30.279	35.225	40.14	45.9	48.3
MODEL	30.338	35.258	40.18	45.1	48.4
	$\upsilon = 11$	$\upsilon = 12$	$\upsilon = 13$	$\upsilon = 14$	$\upsilon = 11/6$
MINIMUM					
OBSERVED	MERCURY	RCMaB	M5	N ~~M~~GC6822	U.M.I.
	26.509	32.340	37.3	41.9	46.6
MODEL	26.782	31.702	36.6	41.5	46.5

Log_{10} grams

This remarkable correspondence suggests that the relations suggested by these dimensionless constants in nature could be generalized. If we could think scale-wise, that is, replace atoms with stars, the data from observational astronomy could be generalized in this manner. This would be one way that would afford a way to go from level to level in hierarchical structures. In other words, we could make the proper substitutions in making the proper modeling,to include all the levels of physical entities observed.

We get out more than
we put in.