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THE QUEST FOR ULTIMATE REALITY AND MEANING: A SCIENTIST'S VIEW*

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1. INTRODUCTION

The traditional purpose of an opening talk is to develop the theme of the conference as a focus for discussion. The overall theme is explicit in the title of the Institute: "Ultimate Reality and Meaning" (URAM). The titles of the general symposia reveal the meeting theme: to clarify the roles of different scholarly disciplines--economics, philosophy, politics, religion, science, and the humanities--in an effort to find meaning in our world. This opening talk develops a more specific theme that is consistent with the preceding themes and provides a sharper focus for the discussion: "Unity and Unfolding Diversity, Diversity and Converging Unity". This theme, which may be referred to summarily as "Unity and Diversity", has been chosen because it is directly applicable to the URAM endeavour, provides a conceptual structure for relating the roles of the different scholarly disciplines, and expresses the spirit of science.

*To be presented at the opening session at the second biennial meeting of the Institute for Ultimate Reality and Meaning in Toronto, August 17-20, 1983.

There are many views on the topics that have been chosen to exemplify the theme. Hence, all that I can do is present a view based on my own experience as a scientist and hope that it may serve as a starting point for developing a more consensual view.

Before proceeding, let me interject a personal comment. My first encounter with URAM was through an advertisement for the journal. The words "Ultimate Reality and Meaning" caught my attention, and also struck a jarring note as being presumptious and ill-defined--and possibly indefinable. My colleagues have reacted in the same way. Involvement in an endeavour with such a title can lead to a certain amount of bantering by one's colleagues, and can deter timid scientists from participating. But I have come to believe that the choice of words is a good one. It captures attention and points in the right direction--to the limits of our ability to conceptualize experience in its totality. The boldness and ambiguity of the phrase "ultimate reality and meaning" stimulate thought, much more so than would a more prosaic phrase such as "irreducible knowledge and belief". It is, nevertheless, helpful to interpret the wording in simpler and less absolute terms. After giving the matter some thought, I find that I am unable to improve on the interpretation given by Tibor Horvath (Horvath 1978a):

> "that to which the human mind reduces and relates everything; that which man does not reduce to anything else"

The theme of unity and diversity is developed below in four parts. The first part is an examination of the relationship between unity and diversity in terms of the concepts of "scale" and "resolution", using an imaginary journey in a shrinking spaceship from the cosmos to quarks in order to present

the concepts in concrete terms. The second part is an examination of the roles of different fields of scholarship--aesthetics and the humanities, ethics, religion, and science--in coping with diversity and in gleaning the unity hidden in diversity. The third part is an examination of a philosophical problem, closely related to unity and diversity, that can be expected to play a central role in later stages of the URAM program: the question of what we mean by the word "true". The fourth part is a discussion of the concept of "reality" from the epistemological viewpoint of the sciences, and how unity and diversity enter into this concept.

2. THE COMPLEMENTARITY OF UNITY AND DIVERSITY: SCALE AND RESOLUTION

We may anticipate a continuing interplay between unity and diversity in our quest for ultimate reality and meaning. There is a complementary relationship between these concepts that may be explained by relating them to the concepts of "scale" and "resolution".* The latter concepts may be made more concrete by using a photograph or a picture on a videoscreen as an example. The "scale" describes the area that is covered by the picture--the actual distance (of the view pictured, not the image) between points at opposite

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*The word "complementary" is used in different senses. One is the sense of different parts that are necessary to form a whole. This is the sense in which one speaks of complementary angles in a triangle. It carries the implication that enlarging one part diminishes the other, i.e., if one complementary angle of a triangle becomes larger, the other becomes smaller. The other is the sense of different ways of viewing or describing the whole, with the related implication that one cannot simultaneously look at an object from two different viewpoints. The first sense is involved here: one must decrease the scale to increase the resolution and vice-versa. The word is used in modern physics in the second sense, where it refers to the principle that the state of a system cannot be simultaneously described in terms of complementary variables: the description must be in terms of one or the other, not both. The position and momentum of a particle are examples of complementary variables.

edges of the photograph or screen. The "resolution" is the smallest detail that can be distinguished on the photograph or screen. The larger the scale, the greater the wholeness or "unity" of the view. The greater the resolution, the greater the observable detail and, hence, diversity of the view. The complementarity arises from the finite number of grains in a photographic film or the finite number of lines used to generate a videoscreen image. These finite elements are analogous to the finiteness of our minds. If we want to attain the greatest degree of unity in our comprehension of reality we must examine it on the largest possible scale. We can do this only by sacrificing resolution. But reality is infinitely complex and detailed, and we cannot achieve unity without an understanding of the details. This requires high resolution.

Our first contact with reality is usually a picture with limited scale and resolution. As we attempt to understand this picture, we are led to examine the details, and the diversity unfolds. In order to regain unity, we must gain an understanding of the general principles and logical rules by which the details may be related and fit together into a coherent pattern. A converging unity evolves out of this understanding. This converging unity can lead us to an awareness of a scale that is much greater than the scale we first experienced.

The analogy with a photograph or videoscreen image should not be taken too literally. In our attempts to comprehend reality, we are dealing with ideas that transcend the concepts of resolution and scale defined in terms of distances between points in space. One must replace these spatial concepts with concepts related to the number and detail of the ideas involved and the range of experience to which the ideas are applicable. Use of the concepts of

spatial scale and resolution to exemplify the concepts of unity and diversity of reality is intended only to provide a concrete example for a starting point.

The theme of unity and unfolding diversity may be exemplified by the following imaginary journey. Imagine that you are a visitor from the outer edge of the universe traveling in a spaceship toward the earth from a starting point a few billion light-years away.* At the start, the field of view in the videoscreen of the spaceship is an expanse of black, empty space with a few specks of light here and there. In this view at the largest scale and lowest resolution there is very little observable structure. The diversity is hidden, but unfolds as the journey continues. As we approach one of the specks of light, it resolves into a cluster of many points of light. Each point of light is a galaxy, not yet resolved in the scale of the videoscreen view. There are billions of them in the universe.

As we approach the galaxy that we know as the "Milky Way", we see that it is a flat circular disk with spiral arms made up of gas, dust, and billions of stars. As we enter the disk, we can make out pinpoints of light corresponding to individual stars, and the galaxy itself becomes an irregular band of light--the Milky Way we see in the sky on a dark night. As we approach one particular star, the sun, we see that it is an almost perfect sphere encircled by much smaller spheres that are visible only in the reflected light of the sun. One of these spheres, the planet earth, appears as a bluish-white sphere with a smaller sphere, the moon, orbiting around it. Our field of view has narrowed

*A light year is the distance that light travels in a year. For comparison, the moon is 1.3 light-seconds (0.000,000,041 light-years) away, the sun is 8.3 light-minutes (0.000,016 light-years) away, and the nearest star is about 4 light-years away.

greatly, with a corresponding increase in resolution. But there is still a deceptive simplicity in what we see.

I will leave it to your imagination to visualize the diversity that unfolds as the oceans and continents come into view, and the incomprehensible complexity that becomes apparent as the many different plant and animal species are viewed in a complex physical environment. One particular species, known to biologists as Homo sapiens, is found to be especially diverse--engaging in complex patterns of activities guided by many different cultural, socioeconomic, and religious traditions and institutions.

But that is not the end. Suppose that we could shrink our spaceship and continue the journey into the microscopic and submicroscopic world of cells and atoms and subatomic particles. The apex of complexity in our field of view on the spaceship videoscreen (which we imagine to have X-ray capabilities to see through solid matter) would be reached as we examined the complex cellular structure of the human brain. Then things would get simpler again as our field of view narrowed and the resolution increased. (Or perhaps this is only an illusion that reflects our ignorance.)

The structure of individual cells would still be quite complex, but as we began to distinguish individual molecules, such as DNA and other complex organic molecules that constitute the building blocks of all biota, the complexity would begin to diminish. When we got down to the level of individual atoms, the view would be much simpler; we would find that there were only about 100 different building blocks, the individual atoms from hydrogen up past uranium (including man-made atoms--which are also made in the stars, but don't last long enough to be found naturally on earth).

Our ways of observing must change radically on this scale. The mere act of observing disturbs the system in a way that cannot be described by the concepts with which we are all familiar, and one must resort to the esoteric conceptual and mathematical structure of quantum mechanics. But for the purpose of this discussion, we may describe subatomic particles as if they were macroscopic objects. The matter of which the apparently solid objects on earth are composed is mostly empty space. The atoms consist of very small spheres of dense matter, the atomic nuclei, surrounded by low-density clouds of electrons. (If the nucleus were the size of a small marble--about one centimeter--the electron cloud would extend out to several kilometers.) As we shrank further and plunged into an atomic nucleus, we would come to the end of our journey as we encountered the quarks and gluons that consistute the buildings blocks of all atomic nuclei. The journey might go further, but this is as far as we are able to go without exceeding the current limits of human knowledge.

The span, measured by the ratio of the field-of-view for viewing galaxies in the videoscreen at the start of the journey (10,000,000,000 light-years) to the field-of-view for viewing quarks and gluons in the videoscreen at the end of the journey (0.000,000,000,000,001 meters), is 10^{41} (1 followed by 41 zeros). This is the known spatial span of reality. The temporal span, from the age of the universe (about 10,000,000,000 years) to the shortest span of time that can be measured (about 0.000,000,000,000,001 seconds at the present time) is only slightly less. If we are to conceptualize ultimate reality and give it meaning, we must encompass the diversity within this spatiotemporal span.

This imaginary journey conveys the idea of unity and unfolding diversity. I will not here attempt to develop a corresponding concrete analogy for diversity and converging unity. But the thought that prompted the statement of this converse relation is the manner in which understanding gained by examining the diversity at high resolution on a small scale often enables us to see a unity at lower resolution on a broader scale that previously escaped us. One example in biology is the recent rapid expansion in our understanding of the nature of living matter that followed the discovery of the molecular structure of genetic building blocks--a molecule with a double helix structure known as DNA. An example in physics is the recent developments in our understanding of the origin and fate of the universe. Concepts at the limits of the largest conceivable scale are closely related to, and have been greatly stimulated by, current developments in our understanding of quarks and gluons--concepts at the limits of highest resolution.

The interplay of unity and diversity that has led to recent advances in physics and biology is, I believe, only the beginning. We may anticipate that within the next few centuries, and possibly within the next few decades, there will be even more revolutionary developments in psychology and sociology, and that these developments will have an enormous impact on religion, the arts, economics, politics, and the humanities.

If our quest for ultimate reality and meaning is to bring us closer to the goal of at least making significant progress in understanding and comprehension, we must develop ways of thinking and ideas that encompass and combine all that can be conceived, experienced, and understood at all levels of resolution and all scales. We will be continually hampered by the limitations of

our intellects, which force us to narrow our field of view and reduce the scale of our thinking as we examine the details, and to lower the resolution by ignoring details as we increase the scale. But I believe that we can cope with this problem if we remain aware of it, and adjust and match the scale and resolution of our thinking as we exchange ideas.

3. THE PILGRIM ANALOGY

The expansion of knowledge in the last century has foreclosed the possibility for one human, even a genius, to master all or even many fields of scholarship. The quest for ultimate reality will involve many different fields of scholarship. As each of us approaches the problems of URAM from the perspective of his or her field of scholarship, there is a need for a model or framework that enables us to see the role of our work in relation to the work of other scholars. The use of analogy is helpful for this purpose. An analogy that I have found to be useful in the present context is the "Pilgrim Analogy".*

In the Pilgrim Analogy, one starts from the view that life is a journey, both individually and collectively. There are four requirements for a successful journey: a map, a route, a destination, and the motivation and will to proceed. These are independent requirements; all are essential.

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*Credit for this label should be given to Dr. Frank Budenholzer, S.J., a theoretical physical chemist. When I described the analogy to him at a meeting of the Institute for Religion in an Age of Science at Star Island in 1981, his response was "Oh yes, that's the Pilgrim Analogy." The origin of the analogy traces back to antiquity in the religious concept of a pilgrimage.

The need for a map may be called into question. For the first journey into new territory beyond the frontier, one does not have the knowledge to construct a map, yet the journey proceeds nevertheless. In response, it may be noted that a map is still needed to reach the frontier without aimless wandering, and that explorers usually have an imaginative construction--a vision--of what might lie in the unknown. This vision constitutes a preliminary map and is constructed by inference and extrapolation from the known map of explored territory. For the first journey into unknown territory, one of the goals--often the primary goal--is to construct a map for those who will come later.

It is the function of science to provide a map. The issues involved are those of objective truth: the polarity of true/false. Is the map (or some part of it) a true or false representation of reality? If, as is usually the case, the destination lies off the territory that has been mapped (beyond the frontiers of science), then other disciplines, e.g., theology, come into play. But, as the scientific frontier advances, one may fairly argue on historical and rational grounds that other approaches must yield to science in construction of the objective map. It should also be kept in mind that the map is provisional and subject to change, even though it is the best map we are able to construct at a given time; hence, the map of territory beyond the scientific frontier must be regarded as even more provisional. (I mention this because there is a human tendency to mask these uncertainties by claims of infallibility.)

Because the development of the map of reality needed for the journey can involve more than science, it may be useful to introduce a new term to describe

all human activities involved in developing an objective map of reality. I suggest that the term "knowance" might be appropriate. Science constitutes the major component of knowance. But other disciplines, notably philosophy and theology (and also the arts), are also involved.

It is the function of ethics to lay out the route (in the sense of choosing appropriate means to achieve ends, i.e., to reach a destination). The issues involved are those of normative truth: the polarity of good/evil. Is the chosen route (means) good or evil? If only one individual were involved, this would be a relatively simple task; one need only avoid difficult or dangerous routes and find the safest and fastest (or most enjoyable) route to the destination. The problem becomes much more complex for a society. Individual needs must be balanced against the needs of society, and difficult questions of justice, love, and stewardship come into play.

Ethics has, traditionally, been one of the functions of religion. However, an applicable ethic that establishes appropriate means to ends must transcend any individual religion or culture. Since the word ethics may have established usage that might cause difficulties in interpretation, I suggest that the word "guidance" might be used for human activities involved in establishing a route in the sense of the Pilgrim Analogy.

It is the function of religion to identify the destination. The issues include and transcend those of good (God) and evil (Devil). Since the ultimate destination, which is of ultimate concern, will always lie off the map and is beyond knowing in the scientific sense, I prefer to use the word "vision" rather than destination. Given the inadequacy of our abilities to peer into

the future and predict, the process of constructing a vision might more properly be regarded as the process of providing an individual or group with a "sense of direction." This view gives more emphasis to the self-renewal process needed to modify visions in the light of insights gained from advances in knowledge.

An unresolved problem is the question of what constitutes a valid vision, how and by whom it evolves, and whom we should believe. Buddhists, Christians, Hindus, Humanists, Jews, Marxists, Moslems, and others have different visions (although with many elements in common), and there are no currently known means for establishing one as more valid than the other. I am inclined to regard the question of which one is right as inappropriate and unanswerable, just as it is inappropriate to consider whether a man is superior to a woman or an elephant to a whale. Each is a part of reality, with its own destiny and role to play in the journey. There are common attributes that can validly be placed as restrictions: we should not harm or destroy each other. But the vision that serves to define our current understanding of our destination should otherwise be regarded as multidimensional and should allow for different visions for different groups.

Since many may argue that there is much more to religion than identifying a destination (constructing a vision), it might be appropriate to introduce a new word, "visiance", for the human activity concerned with identifying destinations (including milestones). Religion would constitute the major component of visiance.

Aesthetics, in a general and extended sense, covers those aspects of human experience and human activity that inspire and motivate and give us the will to proceed. The issues involved are those of aesthetic truth: the polarity of beautiful/ugly. Aesthetics appears in religion as ritual, music, and art; in politics as public relations and propaganda; in commerce as advertising; and in all aspects of human life as music, art, and literature. It may, in an extended sense, be construed to include all of the humanities and is also an important part of science. Aesthetics is important for understanding, even in the scientific sense. There are some gestalt aspects of understanding that can be conveyed more effectively by art forms than by the more precise representations commonly used in science.

4. THE PROBLEM OF TRUTH

The original program for the Institute for Ultimate Reality and Meaning was laid out in four stages (Horvath 1978b). The first stage was preparation and outline of the program. We are now in the second stage, the analytical descriptive period, in which the primary emphasis is on compiling a record of the historical development of the concept of ultimate reality and meaning: publishing, reviewing, and evaluating journal articles; and systematic reflection and search for methods for critical study of this material. Systematic study of the material to discover common models or patterns and laws was planned for the fourth stage, following publication of the Encyclopedia as the third stage.

During the compilation stage, the question of the truth content of the many different concepts of Ultimate Reality and Meaning that have been proposed by different religions, cultures, and thinkers does not arise. One may liken

the approach at this time to that of an anthropologist gathering material for a study. The concern is that the material be a faithful (i.e., true) representation of what was thought, believed, and expressed by each of the different religions, cultures, and thinkers. At this stage, the issue of whether the concepts proposed as answers to the questions of ultimate reality and meaning are "true" in a deeper, universal sense is outside the scope of the program if we are to adhere to the original plan.

We will have to face the more profound question of the truth content of the concepts themselves at some point during the fourth stage. It will be necessary to approach this task with great care. If, for example, two concepts appear to be inconsistent, it will be necessary to examine whether this is a language problem (use of the same words with different meanings or different words with the same meaning) or whether the concepts are complementary rather than inconsistent (different dimensions or aspects of the same object). Complementary views arise from viewing an object from different directions, from viewing at different scale or resolution, or from viewing different parts, as in the classic example of three blind men trying to describe an elephant: one from touching the tusk, another from touching the leg, and another from touching the tail.

We can anticipate that after careful examination to resolve language problems and reveal complementarities, we will find that there are irreducible inconsistencies between some of the different concepts of Ultimate Reality and Meaning that have been proposed--including some concepts that are currently accepted by different individuals and groups as being "true". At this point, we should be ready with the best available method for resolving such issues.

I don't believe that we should expect, or even try, to convince adherents to a particular concept of Ultimate Reality and Meaning that their beliefs are less true in some sense than some competing concept. But we should be able to resolve the issues of irreducible inconsistencies in a manner that is convincing to most scholars. In order to be able to do this, we should try to arrive at a concensus, before the issues of inconsistent concepts arise, on an answer to the methodological question: "By what criteria does one resolve competing claims with regard to the "truth" of concepts and ideas?"--especially with regard to ideas and concepts concerning Ultimate Reality and Meaning.

This is an age-old philosophical problem. One would expect that it had long since been resolved. Most of us have resolved the truth problem, individually, for the situations we face in everyday life. But in recent conversations with philosophers, I find that the problem has not been resolved for questions of the kind that are encountered in the URAM program. We will have to make some progress in finding an answer if we are to make progress toward unity from the diversity of concepts of Ultimate Reality and Meaning. We need not expect and, I believe, should not even desire to eliminate, or even reduce, the diversity of beliefs that represent complementary views or differences in expression. But I believe that we should strive for the kind of converging unity that at least resolves true inconsistencies, if we can identify them in a consensual manner. We must make progress on the problem of truth in order to do so. In approaching this task, I would like to call attention to some aspects of the problem of truth that are related to the categories identified in the Pilgrim Analogy.

It is important to recognize and remember the multidimensional nature--the many meanings--of the word "true". Lack of recognition (or of recall) of this aspect of truth is a very common source of confusion and misunderstanding. There is "objective truth"--the trueness or falseness of a "map" of reality, which is the sense in which most scientists use the word. There is also "logical truth", which is the sense in which mathematicians use the word. Bertrand Russell could claim, without being inconsistent, that mathematics is an activity in which one does not know what one is talking about and does not care whether what one says is true. He was talking about mathematics as logical truth, but he was using the word "true" in his statement in the sense of objective truth--the map of reality--rather than logical truth, which deals with the logical consistency of the mapping elements. He was saying that mathematicians are concerned with logical truth rather than objective truth, and that the two are different.

There is also "normative truth", which deals with questions of good and evil; "aesthetic truth", which deals with questions of beautiful and ugly; and "religious truth", which deals with questions of the priorities of ultimate concerns. In order to resolve the question "How do we determine what is true?" and provide the tools that will be needed to deal with many of the questions of Ultimate Reality and Meaning, we will have to explore and clarify all of these dimensions of truth.

Some may argue that truth is a single concept, one and indivisible. The fact that a single word, "truth", is used in many contexts suggests that there is a common element or elements to all of the contexts in which the word is used. But it is clear that the concept of truth has many dimensions and that

we will have to explore all of these dimensions before we understand the concept well enough to apply it to some of the more subtle and difficult issues of Ultimate Reality and Meaning.

5. AN EPISTEMOLOGICAL VIEWPOINT OF SCIENCE

Underlying all concepts of Ultimate Reality and Meaning, whether explicitly stated or implicit, is an epistemological viewpoint that establishes a framework of belief with regard to what we can know and how we know. The issues addressed by the choice of an epistemological viewpoint are central to the issues of Ultimate Reality and Meaning. I would, therefore, like to present the viewpoint that guides my own thinking. It is an example of a class of epistemologies labeled as "realism". Although I am sure that my scientific colleagues would argue with many of the details and also the mode of presentation, I believe that the ideas presented below are fairly representative of the epistemological viewpoints that underly the thinking of the majority of scientists. This viewpoint may be made concrete by the following hypothetical construct.

Imagine that an individual is placed inside a hypothetical bubble, which might be contracted to a surface enclosing a single individual, much like the plastic films that are used to package toys and other small items sold in stores. We may refer to this imaginary surface as a person's "individual enclosing surface," or "I-sphere" for short. Everything that an individual can experience during a lifetime (the "space-time panorama of experience" or "life experience" or, briefly, "experience") is equivalent to time-dependent flux patterns of matter and energy through that individual's I-sphere. We may define everything that takes place inside the I-sphere as internal reality

(for that person); everything outside as external reality; and the sum of the two as reality. External reality is encountered by an individual only through the bounding surface of that person's I-sphere. We cannot reach out and test for the "existence" of external reality outside the limits of our I-sphere, but we may infer the existence of an external reality by the coherence and correspondence of the maps that different individuals construct to correspond to their own experience.

The I-sphere panorama and, by inference, reality are incomprehensibly complex. An I-sphere panorama encompasses the full diversity of individual experience; the totality of I-sphere panoramas reproduces a small part of the diversity of reality. In order to comprehend and respond to a panorama, it must be mapped by symbols and constructs of the mind: words, mathematical symbols, pictures, art forms, mental images, electrochemical patterns in the brain, etc. We use these constructs to point to aspects of external reality and to communicate with each other about them.

It is worth noting that a map of reality can be more "real" to us (i.e., more compelling in thought and action) than reality itself. For example, the state of Illinois in which I live is so multifarious that it is literally unintelligible as a whole. It would be impossible to think meaningfully about it without a map; thus, the map is more "real" to me than the state itself. (I am indebted to Professor Herbert Long for this observation, who also noted that the awareness of this point has roots in antiquity: the point was made by Parmenides in a discussion with Socrates [Plato, 135 B.C.]).

Realism postulates that external reality is not contingent on internal reality (i.e., that which is inside an I-sphere can, at most, have only a minor perturbing effect on that which is outside an I-sphere), and that there exists, in a basic and irreducible sense that cannot be further defined, a total reality that is not contingent on any of the parts contained in the many I-spheres.*

This epistemological view--and, in particular, the assertion that experience (in the sense defined above) and, hence, reality are incomprehensbly complex--has important consequences.** The number and resolution of the mapping elements available to us is limited; hence, our maps will necessarily be incomplete representations of reality. Reality, in its totality, is forever beyond us. Insofar as this definition of reality is concerned, in its totality or in its parts, the concept of "ultimate" reality does not enter. "Ultimate Reality" is a term that applies only to certain aspects of the "maps" of reality that we construct in order to comprehend and respond to experience.

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*It may be tempting to equate this analogy for describing realism in concrete terms with the famous example of shadows on the wall of a cave described by Plato. A close examination will reveal important differences that lead to diametrically opposite conclusions regarding what is "real" and what is not. The concept of the "ideal" is not introduced at the epistemological level in the I-sphere model; the contrast is between the infinitely complex external reality that we encounter through the bounding surfaces of our I-spheres and the maps we construct of this reality and use for communication.

**One should here distinguish between retained experience--those I-sphere flux patterns that affect and alter the internal reality--and conceivable experience, which includes many additional flux patterns (e.g., cosmic radiation or subtle patterns of unperceived significance) that leave little or no trace. These elaborations are discussed in more detail in the introductory presentation of the Science Symposium.

Another consequence of the incomprehensible complexity of reality and the limitations of our means for mapping it is that we must develop and use many different maps at different levels of scale, resolution, and complexity.* For those maps that are constructed according to the methods of science (which, collectively, may be referred to as "maps of science" or, for brevity, "science"), the scale ranges from galactic (the universe as a whole and clusters and superclusters of galaxies) down to elementary particles (quarks, gluons, leptons, and photons). This scale corresponds to distances ranging from 10^{28} centimeters down to less than 10^{-13} centimeters. The resolution can be any distance less than the scale. The complexity ranges from a single hydrogen atom consisting of an electron and a proton (which played a critical role in the development of basic principles of quantum mechanics, one of the most fundamental mapping tools) to the human brain and human societies. Different scientific disciplines have evolved for constructing maps at different levels of scale, resolution, and complexity.

At the smallest scale, highest resolution, and lowest complexity, physics deals with the elementary "building blocks" of reality. We may reasonably argue that physics evolved from and has been driven by the question, "What is the ultimate structure of matter?". This question was (to our knowledge) first asked by the Ionian physicists of ancient Greece many millenia ago. As

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*Scale and resolution refer to the size and detail of the objects of study (see Section 1). Complexity is determined by the number of independent pattern elements that must be used to map the phenomena of interest. There can be low complexity with high resolution even on a large scale if all but a very few of the resolved patterns can be ignored. In this sense, physics is the least complex of the sciences (even though it deals with physical objects at the upper and lower limits of scale and resolution). Psychology, sociology, and many aspects of biology are much more complex.

we move up in scale to lower resolution and greater complexity, we pass through chemistry (atoms and molecules and their reactions), biology (large molecules, cells, organs, and plants and animals), psychology (animals, especially humans, in the contexts of their cultures), and sociology (groups of humans). As we move to larger scale and lower resolution through geology and the planetary sciences to cosmology, the details of lower levels are suppressed and the apparent complexity decreases.

The methods, the models, and even the principles of science at different levels are different, and much of the work at one level involves very little consideration of current work at other levels. But there is a common methodological thread that leads to an overall map. The overall map, which consists of many particular maps, constitutes a coherent whole. This overall map is the converging unity that the human mind extracts from the diversity of our I-sphere panorama. One common thread is the tests used to determine the validity of the map and its parts; these tests are refinements of tests that have been used for many millenia: coherence and correspondence.

I will not attempt to define the concepts of coherence and correspondence in detail. Roughly, coherence is determined by the number of logical elements (elementary symbols, logical rules for combining these symbols, basic postulates, and principles) that are needed to generate the map: the fewer logical elements, the greater coherence. (Aesthetic matters of simplicity and beauty, related to the ease with which the map may be generated and comprehended, also come into play.) Correspondence is the process of mapping selected elements of a "reality map" into selected elements of experience by certain specified operations. The concepts of coherence and correspondence are closely related

to, and generalizations of, the concepts of theory and experiment, which are the essence of modern science.

Viewed in this way, the "scientific method" differs from the methods based on reason and experience that have been used for many millenia only in the rigor and precision with which it has been developed and applied and in the scope of its applicability. The methods of modern science have supplanted other methods that also make use of coherence and correspondence (e.g., theology) in most areas of human experience because scientific methods yield maps that are more coherent and correspond to a broader domain of human experience. They have also greatly increased the scope of perceived experience by using instruments that extend our perceptual ability and by developing concepts that make us aware of more subtle patterns. However, there are still areas inaccessible to the methods of modern science. Whether future developments will make them accessible is an open and muchdebated question.

The scientific endeavor may be likened to the working out of a child's dot puzzle. (I refer to puzzles consisting of a sequence of numbered dots which, when connected by lines, reveal a recognizable picture of some object.) In scientific endeavor, the dots are unnumbered and represent the limited number of encounters with reality through our I-sphere (elements of experience) that we refer to as "experimental facts" or "relevant experience". By themselves, these facts are chaotic and constitute only a small part of experience. The concepts, ideas, theories, and principles that we use to construct patterns to superimpose on, match, and make sense out of these elements of

experience are analogous to the lines of the dot puzzle. The lines do not necessarily correspond to elements of reality.*

It should be noted that although Karl Popper's concept of "falsifiability" is an important part of the correspondence principle for establishing the validity of a part of a reality map, it is not, by itself, enough. Falsification nearly always involves lack of correspondence at one or a few points on the space-time panorama at the surface of a few I-spheres. Lack of correspondence at one or a few points may or may not be serious. It could be due to faulty measurements, faulty interpretations, faulty calculations, or trying to push a theory beyond its known limit of resolution. It is rare that a single measurement reveals a major flaw that requires a major revision of the map. When it does (as in the development of the theory of general relativity), the old map (theory) is often not made obsolete. Rather, the new developments merely define more clearly the limitations of the old map. New maps (theories) enable one to go beyond these limitations, but we inevitably find that they have limitations also. Brilliant and unexplainable flashes of insight by a genius are needed to transcend the limitations at each step. But we can be sure that at each step in our progress toward a more accurate and comprehensive map of reality--the converging unity from the diversity of our experience--the validity and limitations of our map will be established by coherence and correspondence (reason and experience, theory, and experiment) and not by any other authority. But we will never achieve a final and complete map. An "ultimate" map of reality in this sense is forever beyond us.

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*Wave functions in quantum theory are "lines" in this sense that do not correspond to elements of reality.

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