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What Do We Know About Knowledge?

by

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The Brain and the Mind. One is tempted to answer the question, "What do we know about knowledge?" by saying "Not very much." Knowledge is an extraordinarily complex structure, only part of which is accessible to us. Every human being has a knowledge structure, partly accessible through the mysterious operations of consciousness and coded in some way, no doubt in the human body, mostly in the nervous system, and, of course, predominantly in the brain. We do not really have any model of how structures in the brain are coded into images in the mind, and so far, even with all the work on artificial intelligence, we have not produced a conscious computer. I have an image in my mind, for instance, of the Empire State Building. I could even make a somewhat imperfect sketch of it. I could describe it to other people, again rather imperfectly, in language. I also have an image of my brain, in which unquestionably my image of the Empire State Building is encoded. But I have no image whatever of the Empire State Building in my image of my brain. We know, of course, that we can do computer graphics, turning numbers into shapes, sizes, and structures. And we could probably put information into a computer which would enable it to draw a picture of the Empire State Building. Even if a talking computer could say, "I have an image of the Empire State Building in my mind and I will draw a picture of

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it for you," I am not sure we would believe it.

The knowledge content of a human mind, of course, contains much more than images of objects. It contains images of abstract relationships, mathematics and logic: it contains a very complex structure of valuations and preferences; and, of course, it contains language, music, emotions (I still don't think we have made an angry computer).

Knowledge, moreover, is not confined to the brain, but includes what Adam Smith called "skill, dexterity, and judgment."[1] This type of knowledge might be called "know-how" — the ability to write, draw, paint, sculpt, make things, run a machine, drive a car. hit a tennis ball. ... the list is endless. Skill and dexterity obviously involve more than the brain. They involve the capacities and potentials which are coded somehow in the rest of the nervous system and the muscles, skills which can be made more dexterous by a learning process. Judgment is the process by which we evaluate and correct knowledge structures of all kinds. We change the images in our minds, as when we perceive that something we have believed or imaged is false. Skill and dexterity also are guided fundamentally by judgment. Playing a musical instrument is a good example, especially when reading music. Symbols are transmitted through the eyes to the brain, emerging as a kind of knowledge. This is translated into skilled and dexterous operations of hands or the lips, which are constantly corrected by judgment. When a musician plays a wrong note, this information is transmitted to the ear, or even through the fingers to the brain, which sends information out to the fingers or the lips to correct the mistake. Some people can read music which is translated into images of sound in the mind, but may not he able to play an instrument. Some can play instruments from learned memories without being able to read music.

In the learning process, there is quite frequently a transition from conscious judgment into unconscious skill. Learning to drive a car is a good example. When we are learning to drive we have to be very conscious of every movement. After enough practice these movements become almost automatic. The same may be true of playing a musical instrument. Nevertheless, one still has to be careful. The conscious mind stands behind unconscious skill as a kind of watchdog. I once started to go through a red light because "I wasn't thinking enough." 1 had been thinking about something else. Then my eyes caught a car coming through one of the cross streets and my unconscious skill jammed on the brakes and avoided an accident. But still when I come to that particular stoplight I tend to think, remembering what happened, and instruct my skill to be sure to stop.

There seems to be something beyond skill, dexterity, and judgment in the human mind which can be called "creation." A well trained and skilled artist might make a copy of a Van Gogh painting, but would probably never be able to create one. Repeating a poem that one has memorized certainly indicates that the poem is present somewhere in the structure of the mind. This is very different from writing a poem. Creation and creativity are perhaps the most remarkable and mysterious activities of the human mind, not to be explained by any ordinary learning process.

Knowledge as a Capital Stock. All knowledge, whether skill, dexterity, images, judgment, or even what has been created, is a capital stock, which is a product of a learning process based on a net income of information. Much of this comes in through the senses, though some of it is creatively generated within the brain or the mind itself. Knowledge, however, is not created by a simple accumulation of information. In fact, in a very real sense, information can be the enemy of knowledge, creating confusion and noise. For inputs of information to create a capital stock of knowledge they have to be filtered, interpreted, and transformed into a knowledge structure. Even the sense organs do a good deal of this. The huge number of bits of information that come in through ihe eyes have to be filtered out a good deal before what is perceived takes on the form of an object or a scene. Even in reading and conversation, what is taken in by the knowledge stock is much less than the information which is received. Knowledge is produced by the orderly loss and transformation of information, though what constitutes "order" is a puzzle.

The knowledge stock is also a source of very large outputs of information — in speech, in gestures, in sounds, occasionally maybe even smells (the sweat of fear), though very rarely in taste, which cannot really be transmitted to another person. There is no way of knowing whether my experience of taste is the same as another person's, just as there is no way of knowing how the world looks to a color-blind person on the part of one who is not color blind.

There is also a very large exchange of internal information in "conversation" between different parts of the mind or brain. It was Bismarck I think who said, "I am a committee," and we all have experience of internal conflict, debate, and discussion that goes on within our minds in a fury of internal activity. In extreme cases we find people with multiple personalities, in which one part of the brain is not even aware of what another part is thinking, doing, and imaging. Just what constitutes a switch from one personality

to another is an extraordinary puzzle. lt implies that the mind and presumably the brain are hierarchical structures, with a "boss," the "I" or the "me" to which all other parts relate in some way. We also have the phenomenon that might be called "passion," in which we do things that we do not want to do, in which some other "boss" that is still part of our mind takes over.

Dreams are also an example of the uncontrolled activity of the mind. The mind is an immense storage house of past experience, both external and internal, with a huge capacity for putting little pieces into larger wholes. In dreams we experience images and events which we have never experienced before, although they are composed by putting together images, perhaps somewhat at random, in bits and pieces from previous experiences. We may all have had examples of dreams that were startlingly unfamiliar, not closely related to any previous input.

Experiences that might be called "broadly religious" are by no means uncommon and are well documented, though not perhaps universal. The descriptive writings of the mystics have a certain coherence, even if the origins of these experiences are obscure. William James' famous study of the varieties of religious experience certainly suggests that experiences of this kind are very widespread among all classes and cultures.[2] Meditation is an experience — one might almost call it a skill — which is widely practiced across all the world religions. There seems to be no record of a human culture without something that could be described as a religion, although the practices take many different forms, from the bloody human sacrifices of the Aztecs to the centering-down of the Quaker meeting for worship. This suggests that there is something in the human genes which gives the human mind and brain a potential for such experiences. Whether there is extrasensory contact between minds I am not sure. Certainly there are some people whom we meet with whom we have empathy and others with whom we do not. But whether this is the result of very subtle messages that come through the eyes and the ears, perhaps even the nose, is very hard to tell. Looking into another person's eyes sometimes produces subtle, almost imperceptible communications and messages, which can have profound effects on the knowledge structure and on valuations, without our seeming to be able to identify the content of these messages.

Images of the Future. A very important aspect of the knowledge problem is how we derive our images of the future. This is important because all decisions represent an evaluation of an agenda of images of the future, and then the selection of the one which is valued most highly. Strictly speaking, all we have to do is to divide our images of the future into one that is "best"

and the others that are “not best.” The economist’s theory of maximizing behavior is based on the principle that everybody does what he or she thinks is best at the time. This does not rule out later regret. It has even been suggested that we should minimize regret, though how we can do this I am not sure.

Images of the future can only be derived from our images of the past because we have no experience of the future. The metaphor of a “loom of time" is a good one. We see patterns in the cloth, being woven in the present, that stretch out into the mists of the past, and we project these patterns into the future. There are many different patterns and many different ways of doing this. Where we have a system with constant parameters which are known and an accurate record of its past, we can project it into the future with great accuracy, as we do, for instance, with the solar system, where the gravitational constant (G) has certainly not changed since we have been recording observations. A tennis ball is a bit like a planet. We are able to hit it because we have projected its path, even perhaps its rate of change of acceleration, something which we do not have to bother with in celestial mechanics very much. If a structure has not been observed to change in the past, we tend to project it unchanged into the future. Sometimes we can be very wrong, as when an iceberg turns over or an old legitimacy collapses, as we have seen in this century in regard both to empires and to communism.

A common pattern that we perceive in the past is that of a plan or a program. Babies grow up into adults and eventually age and die because we are programmed this way by our genes. The human race has certainly observed this pattern ever since it has been around. When we have an equilibrium system that has cybernetic processes, we can be fairly confident in predicting its future if the system itself does not break down. It is very much easier to predict the temperature of a room that has a thermostat than it is to predict the temperature outside. Similarly with our ecological equilibria, as in a pond or a forest or a prairie, a disturbance of one population is likely to lead to an eventual restoration of the original condition. If one population in an ecosystem is below its equilibrium level, individual members of it will find it easier to eat and a little harder to be eaten, there will be more births than deaths, and the population will grow. If it is above the equilibrium population, its members will find it harder to locate food and easier to get eaten, so the population will decline. At the “equilibrium population,” births and deaths will be equal. This is characteristic of many kinds of systems. On the other hand, if we have positive feedback, which sometimes happens — this would be like a thermostat that turned the furnace on when it was too hot and off when it was too cold — there will be wide fluctuations which are very hard to predict. Forest fires are a good example. Organized stock and

are necessarily obvious in others. The development of non-Euclidean geometry is a good example. Euclidean geometry is obvious on a plane, but it is by no means obvious on a sphere, still less obvious in four-dimensional space-time, as Einstein demonstrated. We have similar problems with algebra. It is obvious that $(A+B)^2$ equals A^2 plus B^2 plus 2AB. We can show this geometrically on a plane, though not a sphere. We really need a non-Cartesian algebra, especially for the social sciences, where, for instance, minus-minus is not necessarily plus, and where equations do not necessarily equate. Not doing harm is very different from doing good, and some people are more equal than others. Nevertheless, there are some very useful identities. One, for instance, is what I have called the "bathroom theorem," that the increase in anything is equal to the additions minus the subtractions, which is the basic theorem of demography and of all populations.[3] Many of the "laws," even in the physical sciences, are based on identities. The inverse square law rests on the principle that the area of a sphere is proportional to the square of the radius. Ohm's Law, that current is proportional to potential difference divided by resistance, is an intuitive definition of resistance. We also have the Fisher Equation in economics, that PT = MV, which rests on the identity that exchange is of equal values and provides us with an intuitive definition of the velocity of the circulation of money. Even the Keynesian theory is based on the "bathtub theorem," in the form that anything that has been produced by businesses in a given period has either been bought by households or is still held by businesses.

The Elimination of Error by Disappointment. Another source of the elimination of error is disappointment, that is, a prediction that does not come off. This is basic to experimental science. An experiment is based on a prediction as to what will be the result of doing certain things. If the prediction comes off then the theory that the experiment was based on tends to be confirmed. If it does not come off, there is disappointment, and several possibilities emerge. One is that the prediction was wrong and should have been different, which means going back to the drawing board, constructing some new theories and predictions based on them. It is not unknown, however, for people to decide that the disappointment was an illusion and was caused by some accident or unknown in the system. Various reactions to disappointment are common in ordinary daily life. If I take a pill for some ailment and it doesn't work, I am disappointed. I may decide that I took the wrong pill, I may decide that I had another bug, I may decide that I was really OK and just imagined that I was sick, or I may decide that the pill was no good.

commodity markets are sometimes like this. The Great Depression of 1929-1933 was also an example.

It is very important to recognize systems that have information as an essential element. In these systems there is a nonexistence theorem about exact prediction simply because information has to be surprising or it is not information. We cannot predict what we are going to know in the year 2000 or we would know it now and would not have to wait, though we can make guesses of greater or lesser degrees of probability.

The Perception and Correction of Error. A very critical question in regard to human knowledge is the nature of error in the knowledge content of our minds, and the processes by which error is detected and corrected. Philosophers have debated whether error is a failure of coherence or a failure of correspondence with some outside real world. I must confess that despite some evidence to the contrary, I believe in the existence of a real world and hence would certainly argue that what we mean by error is the failure of images in our mind to correspond to, or "map," what they are supposed to represent in the real world. Then a question arises as to whether the real world itself is coherent. This is a surprisingly difficult question, particularly in the light of fashionable chaos theory. I sometimes tell my students that if the real world is a muddle, it is a great mistake to be clear about it. Certainly the real world changes and has probabilities. Especially as we get into biological and social systems, it becomes very clear that the structure of the past is a result of the time at which improbable events happened. Even the formation of DNA, which started off biological evolution, seemed like such an improbable event to emerge out of chemical evolution that Mr. Crick, one of the fathers of DNA, ventured the opinion that it might have come from outer space. But that does not solve the problem either. The development of *Homo sapiens* may have been almost equally improbable, because it involved a long series of mutations increasing the size of an organ, the brain, which nobody was using much, the capacity of which is still very far from being utilized.

The Perception of Identities. Nevertheless, we do have the capacity to perceive that not all things are possible. One of the great triumphs of the human mind is logic and mathematics, which consists mainly of the perception of things that are obvious, that is, that cannot be otherwise. These perceptions are very important in limiting our image of the real world to what is possible and even, to some extent, to what is probable. We always have to worry, however, whether or not things that are obvious in one environment

Success tends to confirm our previous image and we do not learn very much from it. Failure, on the other hand, tends to change our image, though not always for the better. Failure, however, is essential to the learning process, and a good deal of the success of the scientific subculture in increasing human knowledge can be attributed to the fact that failure was legitimated, that if an experiment failed one was supposed to publish the results anyway, though this did not always happen. Popular proverbs illustrate these dilemmas: If at first you don't succeed, should you try, try again? Or should you adopt the sour grapes principle, that what you tried doing wasn't worth doing anyway?

Another very important source of the detection of error is the keeping of careful records, continuous over time, in which patterns can be detected. Thus, it was the careful observations of Tycho Brahe, night after night, on the position of the planets that led to Kepler and eventually to Newton. In economics, the keeping of national income statistics, which we have had for 60 years now, has revealed a pretty wild system, but one which is not without some regularities.

A fourth source of the detection and correction of error, not perhaps widely recognized, is the recognition of uncertainties and probabilities in the real world, so that we do not have to decide whether a particular image or proposition is absolutely true or absolutely false. The weather forecasters have caught on to this, particularly when they say that there is a 50 percent probability of rain tomorrow, which means that either it will or it won't.

The Impact of Valuations. Another very important aspect of the knowledge structure is the impact of valuations on the other patterns of knowledge. Valuations are part of the knowledge structure. We constantly put valuation fields over our images of the world. Some we value as "good," others as "less good," others as "bad," still others as "very bad," and so on. It was a curious illusion of the logical positivists that valuations were not a part of the real world. In reality our knowledge structure, including valuations, is itself part of the real world. This comes out very clearly in things like the Heisenberg Principle, where asking a question can change the answer. We find this now even in the physical sciences, and, of course, in the social sciences there are Heisenberg principles all over the place. One cannot give people a questionnaire without changing their opinions, as you may ask them questions they have never thought about before. Predictions may be either self-justifying or self-defeating if enough people believe them.

Valuations as Hindering the Elimination of Error. Valuations, however, may also affect our capacity for diminishing error, if change threatens some of our significant valuations. Evidence against a highly valued error tends to be rejected and the error sustained. We see this even in the sciences. Certain views of the world become fashionable and respectable and alternate views tend to be rejected and even diminish the valuation which other people put on the person advocating these views. Sometimes, however, evidence mounts up until it becomes overwhelming and then the images change. A very good example of this is in geology. The idea of continental drift was rejected for a whole generation or more by respectable geologists and then evidence turned up in the mid-Atlantic which made the doctrine extremely respectable. In social systems, this problem is perhaps even greater. Marxism, for instance, gives a very inadequate account of the social system, though it has some insights. It is not labor that produces value, and certainly not labor that increases wealth, but the imaginative entrepreneurial use of capital. There is really no such thing as a working class. There is an immense variety of occupations and interests. Revolution tends to create Stalins. The evidence for the inadequacies of Marxism was piling up year after year after the Revolution, but was firmly resisted by the Marxists because of the high value they put on their own image of the world. But finally the evidence became too great and the whole system collapsed.

Knowledge as a Social System: The Ethos of Science. All this emphasizes the fact that knowledge is not just an individual personal structure but is a pattern in social dynamics affecting all members of the human race. Teilhard de Chardin's notion of the "noosphere," the sphere of all human knowledge as it stretches around the earth in human minds, is a concept at least as valid as the biosphere.[4] There is constant interaction as a result of communication among the images that people possess. An input of information, as we have seen, changes the knowledge structure of a person. The exchange of information changes the distribution of the knowledge structure.

Science would not have expanded human knowledge so much if there had not been a culture of communication among scientists which reinforced what might be called an "error diminishing ethos." Virtually all scientists share an ethos, that is a set of valuations applied to their own and the larger environment. This includes, for instance, a high value placed on curiosity — What's the world really like? There is also a high value placed on veracity. One thing that gets a person expelled from the scientific community is being caught in

lies, or in falsifying one's results. There is also a high value on some form of testing, though the particular form may depend on the field of knowledge that we are concerned with. There is also a high value on the abstention from threat, on the principle that people should be persuaded by evidence and never by threat. When these principles are transgressed, as they were, for instance, in the Soviet Union, in the Lysenko case under Stalin, which destroyed genetics for a whole generation in the Soviet Union, science withers.

Knowledge from the Records of the Past. A very important principle here also is that because of writing, fossils, and other records, we have communication with the past. The accuracy of this communication may depend on the way in which records have been created, and especially on whether they have been created carefully and honestly. Again, the work of Tycho Brahe is a good case in point. Our images of the past constantly change as new records and new forms of records, like carbon-14, are discovered. We always face the problem that the records of the past are a very small sample of it and almost inevitably a biased sample, biased by durability. Writing is durable, conversations are not, except in human memory, which is also not very durable. Bones and shells are durable, flesh usually is not. Nevertheless, we can develop skill in interpreting the records of the past, partly by skills that we have in detecting impossibilities and improbabilities. It is unfortunate that human history as it is usually written is a remarkably imperfect sample of the past. Historians tend to be interested in what is interesting rather than in what is important. This is something one hopes the future may correct.

Folk and Scholarly Knowledge. We can make a useful distinction between the folk knowledge of ordinary daily life and the scholarly knowledge of specialists in knowledge. I prefer the word "scholarly" to the word "scientific" because from the point of view of the general knowledge structure the distinction between the sciences and the humanities is not great. Indeed, we probably know more about Queen Victoria than we do about the dinosaurs or even the ice ages.

Folk knowledge is often quite accurate. We know how to get around our own neighborhood or else we would not last very long. Failure is often visible and identifiable. If our house burns down we would certainly know about it. Even societies without written records or any scholarly knowledge often develop an oral tradition of knowledge about their own environments which develops through a long process of trial and error, and this can be pret-

ty accurate, more so sometimes than that of the scholars who visit them. On the other hand, folk knowledge can go wrong as it edges into myth and superstition, simply because the human mind has an extraordinary capacity for imagination and for building up images that cannot be tested. It is ironic that images that cannot be tested often are more stable than images that can be tested. The first cannot be found out and the others can.

Appropriate Methodologies for Scholarly Knowledge. Scholarly knowledge can also go wrong if it becomes an orthodoxy using threat to perpetuate itself. It can go wrong also if inappropriate methodologies are used, perhaps taken from a more prestigious to a less prestigious field. Each field of knowledge has to find the methodology which is appropriate to it and this is not always easy. The following are suggested as a rough classification of the various methodological fields.

(1) First we have fields which have stable parameters, easily quantifiable events and structures, where information is not an essential part of the system itself. Celestial mechanics is a prime example. Predictions can be exact, of such things as eclipses; observations and records can be easily quantified, the position of an object in the sky can be reduced to two numbers (latitude and longitude), even if these numbers are arbitrary. The underlying principles, like the inverse square law, are essentially truisms, and the parameters are remarkably stable. The gravitational constant G certainly has not changed in the lifetime of science. Cosmology is a little more dubious. The assumption of cosmologists that the parameters we detect around here are the same everywhere, like the velocity of light and G, suggests that they are not very much worried about sampling.

(2) A second sort of methodological field has stable parameters but complex systems that are nevertheless sufficiently free from rare events for systematic manipulation to disclose their parameters. These are the experimental sciences, of which, of course, chemistry and physics are perhaps the most successful, and biology is successful up to certain levels of complexity. In psychology, I must confess I think, particularly in regard to human psychology, the systems investigated are so complex that experiment has only a limited value and quantification can be very deceptive. The more complex a system, the more important is its structure and the less important its quantities. The weight of a human being tells us something, but not very much about the person, and the same may be true of an I.Q.

(3) Systems that have rare and improbable events are unsuitable for the experimental method. Here we have to go to observation and the collection and discovery of records. Evolution, both biological and societal, is a very

good example. Evolutionary processes are not determinate. Our universe is one out of a very large number of universes that could have happened. It contains certain patterns and regularities which can be detected. Quantification becomes very limited in its value. The number of individuals in a population is an interesting number, but entirely fails to describe the differences among individuals, which may be very large. As we get into social systems, quantifications can actually be quite deceptive. Price indices, although they tell us something, are inherently inaccurate, for we cannot say what the price of a color television set was in 1920 unless we say that the price was infinite and the quantity was zero, in which case infinity multiplied by zero is any number we want to write down. The GNP likewise is useful as evidence, but two countries can have the same GNP or the same GNP per capita and be extremely different.

(4) Large and complex systems have to be sampled, and the more complex the system is, the harder it is to know how representative the sample is. Sampling theory assumes a pattern in what is sampled that may or may not be realistic. At some point stories may tell us more about the system than numbers. And copying the methodologies from simpler systems, like celestial mechanics, can be quite disastrous. In systems with information, furthermore, as we have noted earlier, there is nonexistence theorem about exact prediction. We have to put up with irreducible uncertainty.

What all this amounts to is that the process of the increase in human knowledge produces evidence rather than truth. Sometimes the evidence is extremely good, and we can have a great deal of confidence in our images. It is a great mistake, however, to mistake evidence for truth. The knowledge process is a process of the reduction of error, which is enormously valuable. But it is highly improbable that error can ever be reduced to absolute zero. Under some circumstances believing in absolute truth can be a hindrance to the reduction of error and endangers of the quality of human knowledge.

The Role of Integrative Studies. What do all these observations about knowledge have to do with integrative studies? It is clear that there is far more to know than the mind of any single human being can possibly contain. The "noosphere," that is, the total knowledge in all the minds of the human race, is orders of magnitude larger than the contents of the most knowledgeable human mind. The tremendous expansion of the "noosphere" which has taken place throughout human history, and especially in the last 500 years, has happened because of specialization and variety and the development of "disciplines." Even in the earlier days of the human race, a tribe in a tropical forest would know very different things from a tribe in the Arctic. If they are

isolated, as they probably would be, they certainly will not learn from each other.

The same kind of isolation happens in scholarly knowledge, which is divided into "tribes" called "disciplines," some of which interact about as much as the Arctic and tropical forest tribes. Even within the disciplines, there are subdisciplines and specialties that hardly talk to each other, and even within these there may be "coteries of co-citation," groups of people who only quote each other and nobody else.

Specialization, up to a point, undoubtedly increases the "noosphere." On the other hand, economists know that the division of labor, that is, specialization, while it increases the total product, is no good without trade. Otherwise, the clothier would starve and the farmer would go naked. Beyond a certain point, therefore, if scholarly knowledge is to be useful, and if it is to continue to expand, there must be "knowledge traders" who are acquainted at least with the products, if not necessarily possessing the skills, of the specialists.

There are several kinds of knowledge traders:

(1) All teachers are knowledge traders, transmitting knowledge from their own minds to the minds of students. This situation is different, however, from commodity trade, because knowledge is not conserved. In a commodity exchange the seller gives up what the buyer receives and the buyer gives up what the seller receives, that is, there is a redistribution of assets but no immediate creation of them, although trade may provide an environment in which production can be increased. In the case of knowledge, however, the teacher does not lose what the students gain, and indeed should also gain knowledge. I have always felt that if I didn't learn something myself when I taught a class, the hour was wasted.

(2) There are knowledge journalists who translate the jargon of the specialists into the general language, such as the people who write journals like *Science News, Scientific American, American Science*, and so on. This is a very important function. Perhaps the Association for Integrative Studies should have a special section for these people, because they do tend sometimes to be rather isolated from the main body of the knowledge community.

(3) There are also knowledge synthesizers, into which category I would put most of the membership of the Association for Integrative Studies. This can include several subcultures which can easily become specialties of their own. One is general systems, as represented by the International Society for Systems Science (originally the Society for General Systems), an organization of which I was one of the founders and its first president. When the society was founded (1957), we defined a general system as any theoretical system which was of interest to more than one discipline, which was a little

broad. Since then, the interests of the Society have narrowed somewhat, with some concentration in what I have called "special general systems" — mathematical modeling and the like — and "general general systems" — which is the broader philosophical approach. Several theoretical structures which cross disciplines may be mentioned: demography, cybernetics, ecology, evolutionary theory, conflict studies, living systems (as expressed in the work of James Miller[5]), information and knowledge systems themselves, growth systems, and so on. I have always felt that the understanding of these systems is something that should be taught in high schools, as it would be an excellent foundation for more specialized studies.

Another problem for knowledge synthesizers is that of exploring the contents of what should be the "core" of knowledge that everybody ought to know. We could perhaps visualize total knowledge — the "noosphere" — as a globe, the surface of which consists of all the specialized disciplines, with knowledge becoming less specialized as we go towards the center or "core." Every person's individual knowledge structure is a kind of mine shaft which expands in diameter as it goes toward the core. The core is what everybody should share. Then the layers between the core and the surface represent areas of knowledge of which the individual knows a smaller and smaller proportion as we move towards the surface. There is a certain distinction perhaps between a "reading" and a "writing" knowledge. We may, for instance, have a reading knowledge of mathematics without being able to write it very well. Just what constitutes the "core" is, of course, a matter of great dispute. And every discipline will want to get its own arm into this. But even if the solution to the problem remains in constant dispute, it is something that we always have to think about.

4) A further problem for the knowledge synthesizers is the development of discipline. There is some danger that the interdisciplinary can become undisciplined. Discipline is partly an individual matter, but much more a matter of the nature of the culture and communication. I once defined a "discipline" as a subculture of learning within which a young person could get promoted for pointing out that an older person was in error. The constant review of one's own knowledge structure and statements by others is a very important check on error. Discipline, of course, is not confined to the group, but is something that each person may have, and the detection of error in one's own views of the world is an important aspect of individual life.

The bigger the "noosphere," the more important does this trade and communication in knowledge become, and the more important it becomes to develop discipline in the interdisciplinary, which is one of the main purposes of the Association for Integrative Studies.

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Endnotes

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