4-D in Biological Education

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Three Infinities

Far as my eyes can reach there are stars and stars,
Nor may the widest lenses find
The awful outpost guarding at the bars
Where no stars lurk beyond.

Out at the farthest reaches of our sight
A myriad nebulae move fast,
A myriad universes in the night,
Intolerably vast.

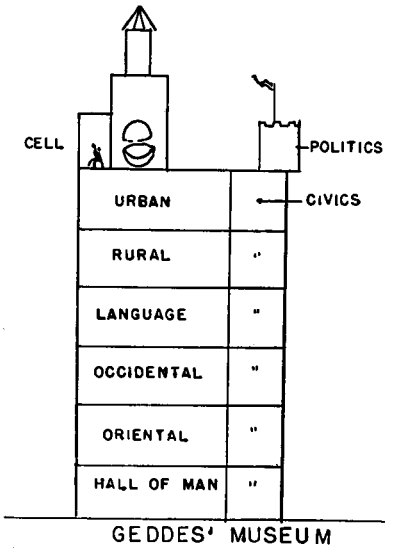
Deep in the hidden atom's sounded cell
Forces divide and subdivide
Beyond the power of any glass to tell
What clashing shapes collide.

In inconceivable minuteness they
Work their strange work and live and die,
Poising a balance in their own sure way
To the yet unprobed sky.

The mind of man undaunted measures these,
Suns, atoms, in unending flight,
And growing like the things it knows and sees
Also is infinite.*

MY FRIEND and one-time neighbor, Martin Sampson, now long since gone to his reward, expressed in the above verse his views on the subject of this special insert. I cannot hope to match his simplicity, or his effectiveness. In the July, 1954, issue of *American Scientist* Dr. Harlow Shapley expresses his views through an article "Cosmography: an Approach to Orientation." I have no intention here of attempting to duplicate his proposal for handling the subject in a program for general education at the university level. In certain details I differ with both gentlemen, and with others dealing with the general subject, in part, of course, because I write for a different audience and for a different purpose.

Possibly the major value of proposals of this sort lies in the fact that they stimulate criticism. I hope that this effort of mine is no exception, even though those criticisms may not find expression in written commentaries. If this attempt provides a pattern for discussion, as well as a stimulus for the same, it will have served its purpose, in part at least. There is no likelihood whatever that every reader will agree with all the details here proposed. Were I again to attempt to orient my views on the subject I probably would modify some details.



Instead of Sampson's "three infinities," I here propose that we think of at least four. These may be four dimensions, giving us the 4-D of the title. At least one of these could readily be broken into one or more mutually exclusive units.

Roughly it seems that any attempt to classify our knowledge of existence might be assigned to four categories, some of which certainly are not mutually exclusive.

There will be those who will say that this attempt to classify knowledge, or aspects of the universe, is wholly inadequate. Whether it is juvenile or profound will depend on the viewpoint and background of the reader. It is not written as a challenge to the ablest thinker, or as a sop to the moron. It may fail in its attempt to be helpful because it does not go all out to meet the needs of either of these audiences. Possibly, because of this attempt to follow a middle of the road path, it will not be of maximum usefulness. However, it is an attempt to help crystalize some of the thinking that has been done along similar lines.

The late Patrick Geddes, author, with Sir Arthur Thomson, of *Life: Outlines of General Biology*, once lay on his stomach in my living room and sketched for me his outline, which he hoped some day to express through a museum. I submit here a tracing of his sketch. He felt that his museum should have seven floors, representing the growth of man through time. His outline obviously dealt primarily with the growth of civilization. His first floor was to be devoted to the evolution of living things, up to the appearance on the earth of Man. Succeeding floors dealt with Oriental civilization, Occidental civilization, the growth of Language, of a land or pastoral economy, of an (Continued on page 480)

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THE FIRST DIMENSION

Chief Factors	Elaboration
FUNDAMENTAL OR BASIC MATTER Fundamental Particles Electrons, protons, positrons mesons, and so on Atoms The Elements	Investigations into the nature of fundamental or basic matter have yielded and will yield facts probably causing the most profound changes that modern civilization has ever experienced. Since the ultimate in understanding the minute is not now, and may never be, understood, we choose to represent it by "?????". Familiarity with the atomic world is being rapidly forced on a public only vaguely familiar with the Periodic Table.
MIXTURES AND COMPOUNDS Molecules Molecular Systems including Crystals and Colloids	Since the units selected for consideration of basic material appear in an order representing increasingly complex groups it is obvious why molecules follow atoms and precede molecular systems.
AGGREGATIONS Inorganic Aggregates of Colloids and Crystals Minerals Rocks Meteorites Organic Aggregates Plants Animals Plants and Animals Organic and/or Inorganic Aggregates Machines Designed to Use Energy Using Cosmic and Gamma Rays Using X-rays and Ultraviolet Rays Using Light Rays Using Infrared and Heat Waves Using Power and Light Waves Using Sonic Rays Using Chemical Energy Using Magnetic and Electrical Energy Used in Energy Transfer Ecological Units	Much as molecules are aggregations of atoms so aggregations of molecules may be brought together as colloids without definite chemical formulae, or as crystals with definite structure and chemical formulae. In Nature we may recognize some of these as minerals, including such a common form as water. These minerals may include, or be closely associated with, other minerals to make such combinations as rocks. These combinations vary greatly from simple mixtures, the parts of which may be separated simply by gravity, to mixtures, the parts of which may be separated by heat, by chemical action, by magnetism and by other forces. Man may create machines designed to use various forms of energy to attain various ends, or Nature may have evolved machines, such as plants or animals, capable of carrying on such important processes, for example, as photosynthesis. The plants and animals may make various associations and these may be closely identified with the physical environment to form more or less definite entities. An atom is a complicated structure, but is an entity. The same may be said of a horse or a forest.
SOCIETIES OF ORGANISMS Societies of Common Ancestry Societies of Common Needs Societies of Common Environment Microclimatic Societies Macroclimatic Societies Megaclimatic Societies Societies, Opportunism and the Times Unorganized Societies Dominated Societies Self-governed Societies	It is difficult to think of almost any ordinary living thing that might not in a way be considered a society of organisms. Most plants and animals may appear superficially as entities, yet they may well be dependent on the satisfactory functioning of many organisms. Bacteria may help in digestion within an organism, or fungi may serve as root hairs for trees. The health of a human being may depend on a satisfactory intestinal flora. We are here concerned more, however, with the integrated efforts of many organisms and studies of how these loosely or closely associated groups function as units. If we can recognize the ties that bind these units we may increase their usefulness to us or, if desired, can cause their disintegration and destruction. The whole field of sociology comes into our picture here if we can interpret it broadly and recognize common elements that are factors in societies large and small.
THE WORLD AS A UNIT The Centrosphere The Lithosphere Land Masses Topography Subsurface Lithosphere The Hydrosphere Ground Water Fresh-water Areas Marine Areas The Atmosphere Lower Atmosphere Upper Atmosphere Stratosphere Satellitic Entities The Moon Meteors	Adequate biological education calls for at least some understanding of the world as a unit. This should represent something more than the ability to parrot such words as centrosphere, lithosphere, hydrosphere, atmosphere and stratosphere, although any well educated person should have appreciation not only of the existence but of the nature of these areas. Space ships as realities and space ships in the comics challenge the thoughts of young and old, and the nature of the interior of the earth may affect survival of life on the earth more than all that goes on in the skies. For the most part, however, it would seem that, in the long run, the most substantial progress would come from understanding better than we now do some commonplace phenomena such as the tides, ocean and other underwater currents, tidal sequences as they affect life navigation, and other things.
THE UNIVERSE The Solar System The Sun The Planets Meteoric and Satellitic Systems Stars, Star Families and Star Clusters The Universe	We are concerned here with an approach to a reasonable understanding of the extra-terrestrial universe. Some of the units recognized in this area are suggested in column 1, but the astronomer, the physicist and the mathematician may elaborate phenomenally the elementary units we have presented. Obviously we do not, and probably never may know, the ultimate nature of space, and of materials to be found in space, but any reasonably intelligent person should have some basic knowledge of the field.

STRUCTURAL ASPECTS OF MATTER

Practical Aspects	Educational Aspects
World competition for fissionable materials that may find use in the new atomic age will be accelerated as atomic power comes into use in war and in peace. The successive ages of manpower, horsepower, waterpower, steampower and electricpower brought no more remarkable readjustments in the ways of men than can be expected with the incorporation of atomic power into the everyday world.	Physical science has expanded understanding of the nature of basic or fundamental matter through exact measurement, inspired research and phenomenal prognostication and is giving us a mastery of the physical world not matched by comparable understandings in the affairs of men. Unless comparable understandings in the social sciences are forthcoming, civilization and education must face one of its most serious crises.
In World War II spectacular research by the Germans might have led to their creating an atom bomb had it not been broken up. They were working in the production of molecules of heavy water.	Recognition of the differences between mixtures and compounds, between crystals and colloidal substances, is essential to an appreciation of increasing complexity of basic materials presented.
Normally one does not find, in classifications of this type, that one can consider a machine as representing an entity in a series of increasingly complicated aggregations of entities. Yet machines, whether made by Nature or by man, bring together particular characteristics possessed by their elements and direct them to do a specific service. A rock may combine minerals, but so does a plant. A lever puts suitable materials into positions where energy is properly transferred. It may be largely or fundamentally a matter of degree when we compare a simple lever with an airplane, or a computing machine, or an automatically operated industrial plant. Criticism will be directed at the inclusion of machines in this table, but one can hardly logically claim that machines composed of inert inorganic matter are not to a degree comparable with organic machines, also fundamentally composed of similar material. If inclusion of machines in this table stimulates criticism, it must also stimulate some thought and thus justify its inclusion. Our major factor in our industrial civilization is a machine.	Studies in this area may be given undue emphasis in any educational program. The identification of rocks, minerals, plants and animals may be essential to an understanding of the physical world, but it is not the whole thing. Even some may object to the inclusion of plants and animals as a part of the physical world. They are, however, tangible, objective and as such may appropriately be considered here. The educated persons should have some concept of the factors that make up most common aggregates, whether it is a peat bog, a cranberry plant in the bog, the juice of the cranberry plant, or the sugar molecule in the juice. Recognition of entities, and how they are associated into larger entities between molecules and ecological societies, is the area here emphasized. Obviously this includes the major portion of the units given greatest emphasis in the general biology course. The inclusion of machines as entities, whether they are living or inorganic, may raise some questions, but it is hard to find a more appropriate section for their inclusion.
The factors suggested in column one should provoke profitable thought and discussion. Societies based on ancestry are well illustrated in pure stands of trees pure cultures of microorganisms, or great schools or herds of creatures of a kind. Again, societies based on common needs, such as food, may be represented by herds of herbivores, such as flocks of sheep and goats that have common foods and, possibly, common enemies. Societies based on environment may well be best appreciated by studying what goes on in microclimates to aid in understanding what goes on in larger units involving climate. In this sense, a forest as we see it is intermediate between the little forest of a single twig and great forested areas covering continental areas. Time may well affect most of these, and there may be an evolution from complete lack of organization through disciplined integration to disorganization and chaos.	Probably the greatest menace to world peace lies in the lack of progress in the field of social science, but this progress is impaired by at least two resistance areas. The social scientists seem as unwilling to understand the basic story of natural science as are the natural scientists to appreciate the importance of putting their findings to work through applying what is known in the field of the social scientists. Too many want to become leaders in a field without developing adequate breadth to assure good judgment. Because a man is a great atomic physicist does not give him necessarily great authority in social science, and because a man is a great politician, writer, actor, speaker or statesman does not necessarily qualify him to express the best judgment in the field of physical and natural science. Somehow, if our civilization is to succeed, we must meet this challenging situation safely.
This unit, of course, is basic geography and, as such, it touches the field of economics, of history, of citizenship, and to some extent of philosophy, if we attempt to interpret all the various situations suggested to us by the geographers. However, one may often find more significant information in the publications of the ecologist than in much that appears as geography. This area of human knowledge has been presented in too many ways to permit complete coverage here. Who is to say that the physicist may not contribute as much to the understanding of the real nature of the world as the stratigrapher, the paleontologist, the soil technician and the cartographer. Somehow and somewhere the well-informed citizen will find something of merit and something appropriate to his needs in the investigations of most students of geography.	In schools some of the problems that may need to be met in this category center around evaluating such things as planting crops according to the phases of the moon; using divining rods to locate water, minerals and other substances underground; consulting solarlunar tables to predict luck in fishing; taking too seriously much that is found in many almanacs; taking too seriously the possible calamities and the possible freedom from calamities that are preached by many who depend more on inspiration than on intelligent investigation by themselves, or by qualified students. An informed public, reasonably sensitive to the story of the changes that have taken place, and will take place in the earth, is more likely to be a happy public than can result from a public frenzied by calamity howlers or asleep because of ignorance or misinformation.
To the average citizen this area may be identified with the astrologer, whose teachings carried greater influence in the past than in the present, and yet whose influence has too frequently in recent times been taken seriously by those in a position to cause catastrophe. Hitler might be a case in point. It is certain that the time spent by some on the study of palmistry, mythology and astrology is not always well spent, and there is so much that needs to be known that we can hardly afford to waste time.	Earlier inserts in *Nature Magazine* dealt with the "Sky at Night." Certainly it is more worth while to know something of the magnitude, period and distance of stars than to know myths about them that so frequently pass as mastery in the field of astronomy at the pre-college level. There is obvious cultural value in knowing what others believed in the past, but as a rule textbook materials at pre-college levels in astronomy are too involved, or too false, to make the contribution that should be made to the average citizen.

THE SECOND DIMENSION

Chief Factors	Elaboration
ENERGY AND THE PROPERTIES OF MATTER Radiation Cosmic X-ray and Ultraviolet Light Rays Infrared Rays Heat Rays Microwaves High-frequency Waves Radio Waves Power Waves Sound Waves Macrorhythms Energy Sources arising from Molecular Nature of Matter Chemical Nature of Matter Gravity Energy Transfer	While philosophers may, with some logic, argue that there may be no hard, fast dividing line between matter and energy, we here elect to consider energy as it affects matter subjectively, or to group it with a consideration of the properties of matter that obviously is subjective. In addition to asking some consideration for the nature of radiation, we ask here for at least an approach to understanding or knowing about some of the more important sources of energy. While suggesting a pattern for considering radiation, we elect to suggest, in addition to considering frequencies or waves of short duration, so far as time consumed is concerned, we also give some thought to rhythmic cycles of long duration due in part to movements of the earth on its axis, around the sun and otherwise. Consideration of the properties of matter are too important and significant to warrant the degree to which they are usually ignored in pre-college science programs.
SPACE AS AN ENTITY Space as it Affects Individuals Concept of Parts of a Whole Concept of Relation of Parts Space as it Affects Groups of Individuals Kinds of Groups Density of Groups Extent of Groups	An understanding of the simplest nature of space is essential. We are here concerned with an appreciation of this. Cells may be entities. Combined they make tissues. The tissues combined may make a plant or animal. Combinations of these organisms occupy still more space as societies. All of these expanding groups vary, as suggested in column one, and special problems arise as these groups get more comprehensive and more complicated. In most of these, space may be an important factor.
TIME AS AN ENTITY Nature of Sequences Sequences Without Order Orderly Sequences Sequences as They Affect Individuals Sequences Without Order Orderly Sequences Sequences as They Affect Groups Without Order Orderly Sequences	The past, present and future as it has affected, affects and will affect any physical part of our environment comes into the picture here. In some cases we can make a complete mastery of a sequence by setting conditions. In others, as in a life cycle, we can do little about some inexorable situations that will develop. Economically, farmers may be interested in hastening sequential change, such as fattening stock quickly and with a minimum of food and care, or we may be interested in delaying some of the difficulties of old age and extending our life expectancy and period of productiveness. The water cycle is rarely a continuous, repeated series of sequences. The life cycle of an animal or plant follows a more established pattern.
MIND OR INTELLIGENCE AS AN INTERPRETIVE ENTITY AND EXPRESSED IN BEHAVIOR Senses Available Ability to Recognize Orderliness Association Interpretation Communication Significant Differences Symbols and Signs Pictures and Maps Words and Word Groups Alphabets Elementary Numbers Letters Units of Space Units of Time Units of Weight Advanced Geological Time Astronomic and Microscopic Units of Space Periodic Table of Atomic Weights Units of Energy Measurement Units of Value Expressed in Mathematics Educational Measurement Cooperation Use Mastery of Time, Space and Energy Management Generalization Hypothecation Experimentation Broad Interpretation Habit Formation Reasoning Ability Philosophy	Much of the wealth of the world lies in mind or intelligence as a means of interpreting the environment. This involves not only the ability of a human being to learn, but, to a large part, his ability to recognize values in the intellectual gifts, if any, of those organisms on which he may rely for a living. With the coming of the machine age it is less necessary for men to understand how to get along with horses, but when horses were in general use men varied greatly in their ability to get maximum cooperation. A jockey, if successful, knows how to get the most from his mount. A farmer who knows how to handle cattle, poultry and other animals gets more from them than one who does not know them well. We are here, then, concerned with the study of the intelligence or mental ability of living things, including ourselves. Basic ability to sense things is of importance, and animals vary greatly in the senses they possess, use and develop. In the first column we have listed, with some degree of orderliness, qualities that may contribute to the use of mind as an interpretive entity, which may be expressed in behavior. In all probability one of the major weaknesses of much of our educational practices rests on the behavior that recognizes an obligation, not only to the present but to assure a better and happier future. An unselfish, long-range viewpoint may call for a higher type of intelligence than that to be found in some who may make phenomenal contributions in relatively limited areas. How selfish and unselfish interests may be joined for the good of all may call for a type of intelligence not so common as it should be, if we are to look to the future with any degree of comfort.

MATTER IN MOTION

Practical Aspects

While we try to present units for consideration that are mutually exclusive, this is not always possible, and, for simplicity's sake, we have occasionally listed as entities phenomena that are in reality merely examples of such a phenomenon as molecular nature. We have also elected, in the face of possible criticism, to include, under the heading of energy and the properties of matter, consideration of energy transfer and the machines involved in this. Some may prefer to separate some of these possible entities, and they, of course, have that privilege. In the development of this outline we have tried repeatedly to arrange units in possible order of increasing magnitude. Consideration of a machine that transfers energy under this system would logically come after recognition of the existence and nature of the energy involved. Of course, these machines will vary greatly with the nature of the energy being transferred. They will also vary in their efficiency in performing their function.

Analysis and synthesis affect greatly the nature of any study. Many branches of biology may give too great emphasis to analysis and too little to synthesis. The concept of taking things apart and putting them together involves varying concepts of considering smaller or larger units of space. Here we must consider this as it affects individuals and groups, their heterogeneity and homogeneity, their density and extent, all of which are important in a rational viewpoint.

Planning for the mastery of our physical environment, or preventing it from mastering us, depends largely on ability not only to understand the present but to predict the future. Study of the past may be significant in predicting the future successfully. Patterns of sequences, whether they are life cycles, ecological cycles or economic or political sequences, are important to successful living. True, a series of types of weather may not continue on a fixed pattern, but there is some probability that a given pattern may be followed. It is important to all that they have some understanding of sequences based to some extent at least on time, whether this is a simple youth-old age, seed-time harvest, boom-bust or other combination.

Intelligence may be a two-edged sword in some cases. A horse may be trained to recognize and respond to a few words, and this makes it useful to man. If it did not have this intelligence many of the burdens it has borne for man would of necessity have been born by other organisms, possibly by other men. The whole story of communication may give us some understanding of the role of intelligence in mastering the environment. Men recognize that many fur-bearers use scent to interpret their surroundings, and so men, who may not themselves be able to detect the niceties of odor, may yet use scent to master the fur-bearer. The increasing complications of means of communication may be accepted as a partial index of intelligence. A dog, for example, can unquestionably recognize signs, words, groups of words and familiar surroundings, but it is doubtful if he can use an alphabet of any sort. Horses have been reputed to be able to spell and count, but it is doubtful if they are not being guided by more intelligent animals. Birds like crows can count the number of persons in a blind, but not too high. But none of these can use the symbols man uses readily in communicating about units of time, value, space and weight. Not all men can have any appreciation of the fact that, too frequently, we do not get the most from our mental ability. We may accept recognition of things as adequate accomplishment. Unless the succeeding steps are taken to include association, interpretation, measurement, management and so on, and unless this is checked and used to attain some further desirable goal, and unless it results in habits of improved behavior, we have fallen short.

Educational Aspects

In examining science programs for use at pre-college levels it is obvious that adequate consideration is rarely given to the properties of matter, the understanding of which may be essential to understanding of the properties of groupings of different kinds of matter. Look through the texts for adequate and appropriate consideration of such properties as elasticity, ductility, adhesion and cohesion, malleability, plasticity, viscosity and with states of matter, with hardness, with fracture, and it will be noticed how frequently students are asked to understand involved studies of matter without first getting some mastery of its elementary nature. They are asked to appreciate wholes with little understanding of the parts. Often, too, the presentations are so involved that recognition of everyday examples of the phenomena being considered is not given. The nature of solids, liquids, colloids, gases, of crystals and amorphic substances, of melting points, of what is meant by mixtures, tinctures, solutions and so on may be involved.

Growth is almost synonymous with life, and growth implies increased use of space and need for space. Cytology, histology, morphology, anatomy and ecology represent areas of biology based, in part at least, on space. The history of civilization is full of crises based on the demands of growing populations, influence and ambition demanding new places in the sun, new markets, expanding economies, and yet, while space may be infinitely small, it may also be infinitely greater than man and his intimate problems.

The effect of time on individuals and on races of individuals has provided the basis for many important fields of biological science. In some of these we may establish understanding of a reasonably complete series. In others this will be impossible or sketchy. We can learn the essentials of the life history of a wheat plant and can change the nature of future generations of that wheat, but we cannot get a complete picture of how wheat has evolved through geological time. Our study of time then varies from what the husbandman can do to determining the future of the environment that provides him with a living, to demands on our finest intellectual powers in exploring and expanding what we know in phyllogeny and evolution.

Possibly the finest type of living may come from applying superior intelligence to the integration of the efforts of intelligent organisms to worthy causes. It may be true that "where ignorance is bliss 'tis folly to be wise" if all one seeks is personal happiness for the moment, but it would seem that greater happiness to the individual and to society may result where a heterogeneous group of intelligent beings join in attempting to improve the lot of all. Theoretically, at least, society demands the best from those with varied skills, varied interests, varied capacities, varied opportunities and varied satisfactions. The engineer, the teacher, the researcher, the technician, the critic, the laborer and the scholar all add their bit, and each gets his satisfactions in an area that the others might not welcome. It is here that the statesman should make his contribution and unite the intelligent cooperation of all. Education may do much to develop individuals who will get the habit of enjoying doing what must be done where and when it must be done for the good of all. This would be impossible in a community of organisms of low intelligence. It should reach the highest level of perfection in groups of high intelligence, disciplined to responsible acts and resulting in such devices as the codes used, for example, by telegraphers or the more advanced concepts used freely by scientists trained in the physical and biologic sciences. The collection of data, its interpretation, its verification and its use may, of course, in its simplest aspects be used by organisms of relatively low intelligence, but real mastery comes when the individual not only is able to make an intelligent interpretation of his times, and his environment, but when he develops the habit of doing this within the limitations of a conscience that recognizes the rights of others.

THE THIRD DIMENSION

Chief Factors	Elaboration
KNOWLEDGE FOR KNOWLEDGE'S SAKE **Understanding** **Intellectual Curiosity** **General Education** **Research** **Basic** **Amateur** **Helpers** **Technicians** **Engineers** **Directors** **Leaders**	Our first page of charts considered recognition of the existence of matter. Our second considered the subjective ways in which matter might be understood. Neither of these implied a purpose. Here we are interested in how these understandings may be put to use, and how they fit into functional living. We may recognize that matter exists as a reality. We may recognize its properties, but here we want to recognize why this is worthwhile. One of these reasons might be just to satisfy intellectual curiosity and simply to get knowledge for knowledge's sake. We might also be interested in this to round out our general education, or for advancing human knowledge through research activities.
MANAGEMENT, KNOWLEDGE FOR A PURPOSE **Techniques of Management** **Incidental Management** **Advocational Management** **Management as a Vocation** **Agriculture** **Commerce** **Communication** **Education** **Government** **Industry** **Medicine** **Transport** **Investigation and Research** **Leadership**	During the latest war many ordinary citizens trained themselves to do routine jobs essential to our success in the war effort. With peace, many found it fun to make things, using the skills they developed in the emergency. Some carried on these activities as mere incidents, or to gain independence of outside assistance in times of strained economies. Some built boats, bred flowers or dabbled in home chemistry as an avocation. But to many this background of experience might well have formed a basis for a vocation. Of course, all this did not spring from the war emergency, but vocations frequently are based on focusing interests and skills started incidentally, and it is possible that the happiest vocation may be one that uses largely basic interests.
UNDERSTANDING OF MATTER FOR PROFIT **Elements of Profit** **Available Resource** **Status of Resource** **Harvesting Techniques** **Processing Problems** **Transport Problems** **Marketing and Salesmanship** **Ultimate Use** **Nature of Resource** **Non Renewable** **Renewable** **Nature of Profit** **Immediate** **Ultimate** **Sustained** **Techniques of Profit Making.**	Profit, as here considered, should be broadly interpreted not only to include monetary returns but returns in satisfaction as well. It is hoped that it may also be interpreted to recognize profit-making as a legitimate essential of a sound social economy and not as a destroyer of, or a parasite on, the weak. Much as life to any living organism requires growrh, so life to a growing social order requires profit. Without profit there could be no business expansion, no preparation to meet old age, or probable expensive crises, no help from the strong for the weak, no increase in productive capacity; in short little, if any, economic growth. The evils of the profit system lie not in making a profit but misuse of profit, and unwarranted increase in profit by the few to the disadvantage of the weak. Understanding the profit system is a part of wise use of the resources that may be available to us.
UNDERSTANDING FOR RECUPERATION IN A BALANCED LIFE **Role of Recuperation in Complete Living** **Physical** **Mental**	The complete life calls for periods of recuperation mixed with periods of effort. It is important to recognize this as it applies to our physical well-being, and as it applies to our mental activities. Sometimes the recuperative effect may arise from a simple change of area of activity, while at other times a radical change may be necessary. The cycle of work, play, sleep and growth seems to be in most patterns of balanced lives.
UNDERSTANDING FOR PURPOSE OF HELPING OTHERS **Teacher-pupil Relations** **Individual Differences** **Aims and Objectives of Teaching Program** **Content Organization** **Material Aids in Teaching, Texts, etc.** **Evaluation and Tests—Evidence of Progress** **Administration and Finance** **Philosophy of Education**	Here is the realm of the teacher, the social worker, the nurse, and the other groups of individuals who, while making a living themselves, make a major contribution in improving the lots of others. Of course, the first step in such a field implies the desire to make the sacrifices and to put at least some personal ambitions subordinate to the services available to others. Satisfactory progress in this field is not attained by merely having the desire to help. There are recognized patterns of behavior that bring the best results. Some of the more important of these are suggested in the column to the left.
UNDERSTANDING TO MEET ETHICAL AND MORAL GOALS **Ethics** **Aesthetic** **Morality** **Religion**	Any program concerned solely with the mechanics of getting a living from a material world is in the long run futile. The mechanic may fashion materials into a superb machine, whether the mechanic makes an automobile or an army for a powerful nation. Unless that machine is used for the betterment of mankind it might better never be made. How we can develop a generation with habits that result in moral and ethical behavior is one of the major challenges of our age.

FUNCTIONALLY UNDERSTANDING MATTER

Practical Aspects	Educational Aspects
Basically any intelligent animal must have some understanding of his physical and biologic environment. This is essential to living. Some will have a more lively interest and want to know more than is required for survival. Still others may recognize merit in a well-rounded understanding, to assist in meeting probable situations that will arise. The general education viewpoint is in part built on this recognition of the value of a broad base on which to prepare for the great variety of demands that may be expected in a normal life. Research, in its many implications, may be considered as the climax in pursuing knowledge for its own sake. All aspects must be recognized.	The advancement of knowledge for knowledge's sake through the channels suggested to the left represents much of what is taught in the average school and college. Research in its broadest significance calls for encouraging the members of a great team of specialists to work together towards an agreed goal. The investigative habits of youngsters may be dulled by the routine disciplines of the standard school program, but eventually we must recognize the necessity of encouraging the amateur, who may make some startling contributions through unorthodox procedures. We must provide trained helpers, trained technicians who can use the helpers, trained engineers, directors and above all trained leaders.
Repeatedly we hear the statement that individuals are engaged in "getting to know the business." Knowledge is undoubtedly the basis of much success in managing anything, whether it is a farm, an industrial plant, a wildlife sanctuary, or whether it is advancing in a profession. Refresher courses for business men, for teachers, doctors, insurance agents are common examples of adding information to the equipment of a worker, to the end that he may increase his productivity, broadly interpreted. A common device used by educators in this field is the so-called workshop, where teachers bring their background of experience to individuals qualified to help them grow in their chosen field. Improved management in any field may depend largely on successful marshalling of resources to attain an end.	A common comment is to the effect that it would be most unfortunate if everyone had equal skill, equal interests, equal ambitions and equal ability. We would all be seeking identical jobs with calamitous results. The guidance program that has grown in the schools may be valuable in directing individuals into fields where their gifts are appropriate to the probable opportunities they may have to find expression and satisfaction. It would be ridiculous for our school system to train all of our students to raise fish, to read Greek, to repair cars or dissect cats. Probably educators face few more important responsibilities than those identified with recognizing the need for guiding others into professional fields that may prove fruitful and satisfying.
Broadly interpreted, the elements of profit with which we are concerned are outlined in column 1 to the left. Conservation fits into this picture perfectly. Legitimate profit implies a survey of the resource involved to know what may be available, a recognition that there is a harvestable surplus that is more valuable harvested than not, understanding of efficient means of harvesting to relieve drain on the basic supply, understanding and application of efficient means of processing the material, of transporting it, marketing it and eventually of using it. It must be recognized that non-renewable resources differ in the degree to which they may be available to individuals, to society, to a generation, and that each generation should try not only to live within the economy provided by the inherited resource, but has an obligation to increase and improve that resource.	To translate what has been said to the left, let us consider problems associated with commercial fishing. Expensive equipment for carrying on such an activity demands established knowledge that the desired fish are available, that they are available in sufficient numbers to warrant the proposed harvest, and that this harvest may continue long enough to warrant the investment. It implies that the fish to be harvested are not more valuable as food for more valuable forms of wealth. It implies that the fish will be so harvested that the supply will not be unduly injured in the process of harvesting so that their value to the consumer is lessened. It implies an available market and efficient transport between harvesting and marketing points. It also implies that the consumer will make a maximum use of the fish with a minimum of waste and spoilage. All this must fit into a picture that recognizes the right of succeeding generations to make a similar profit.
In New York City it is a standard joke that Navy men come ashore and frequently find recreation by taking their girls for a boat ride in Central Park. The typical "busman's holiday" finds its counterpart when business men play bridge for recreation, professional athletes take rugged vacation trips into the wilds, and professional dancers find recreation in social dancing. Recuperation is a varied feast.	With a successful economy we are gaining increased leisure. Wise use of this may be the most important contribution a science program can make, not only to solving some of the problems of juvenile delinquency, but of extending the period of productive happiness and improving the depressing conditions that may accompany the reduced physical and mental powers that come with old age.
While there are proved patterns of procedure that may be expected to yield superior results, teaching and similar services call for something beyond the mechanics of pedagogy and involve something of the art of education and of teaching. Teacher and pupil differences must be adjusted, individual differences recognized and the other categories, suggested to the left, considered, but the mechanical teacher is as inspiring to cooperative effort as is the mechanical piano. We must have adequate finances and adequate administration to care for some of the chores associated with education, but more than these we must have honest, inspired, intelligent leadership.	It may be important to have intelligence enough to exist, to make a living, to make a profit and to plan a balanced life, but it is doubtful if any of these can carry the rewards that go with a life of service to others. In return for these services society should reward reasonably those who elect to devote their lives to such activities. Unfortunately success in this field cannot come just by running with the pack. Few fields of human endeavor are involved in more sinister, crackpot, lazy schools of thought than is education, and it takes the alert, courageous teacher to evaluate the suggestions offered him by others, and to plan a program that will satisfy his conscience.
Conservation has been defined as wise use, a definition that implies that use is necessary. It is aimed at a more or less mechanical pattern of behavior. Another definition is that it is man living in harmony with the land. This is a step in the right direction, but lacks the dynamics favored by many. The most recent definition that it is science with a conscience, or the conscience of science, may be what we are seeking, since it goes beyond use or even beyond harmonious use, and calls upon ethical and moral checks.	Ethics, esthetics, morality and religion must find some expression in an adequate program in education in any field in spite of what the mechanistic educators may have to say about it. True some educational programs have attempted to offer the shibboleths of religion as a substitute for understandings in science. This is as dangerous as the worst, cold-blooded, disciplined, goalless, mechanistic program. Somehow we must meld the good of all human experience into a program that helps people be happy doing what must be done for everyone.

(Continued from page 473)

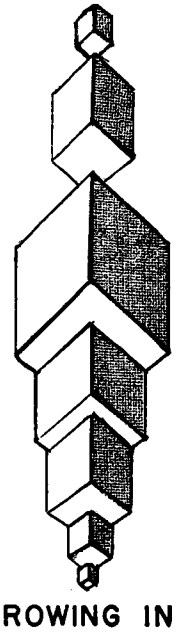
urban economy. His top floor was a variety of towers and pits representing unevenness in progress in man's understanding of the world. He provided orientation by means of a device that would permit one to see where he was in the universe by looking in any direction, up or down, and he had a small tower, called politics, which was in part unsupported by any sound logic.

In the tables on the central six pages I propose that we examine three of the four aspects I am suggesting. The fourth is elaborated on this page of the insert.

As a possible alternative to Dr. Shapley's "The Material Systems," I suggest that we consider "The Structural Aspects of Matter," the details being provided on pages 374-375 deemphasizing some of Dr. Shapley's suggestions, and emphasizing some that he has passed over lightly.

On the fourth and fifth pages of this insert I suggest consideration of our second dimension, or aspect of the problem. There will be those who will contend that consideration of energy, time, space and mind cannot be grouped and that each should be treated as an entity. Since any of the factors suggested on any of these pages may be applied to all the factors suggested on other pages, there is nothing to prevent those who may wish to split the material from doing so. It seemed that possibly energy, space and time might well be considered as matter in motion, and who is to say that mind might not equally well be classified there?

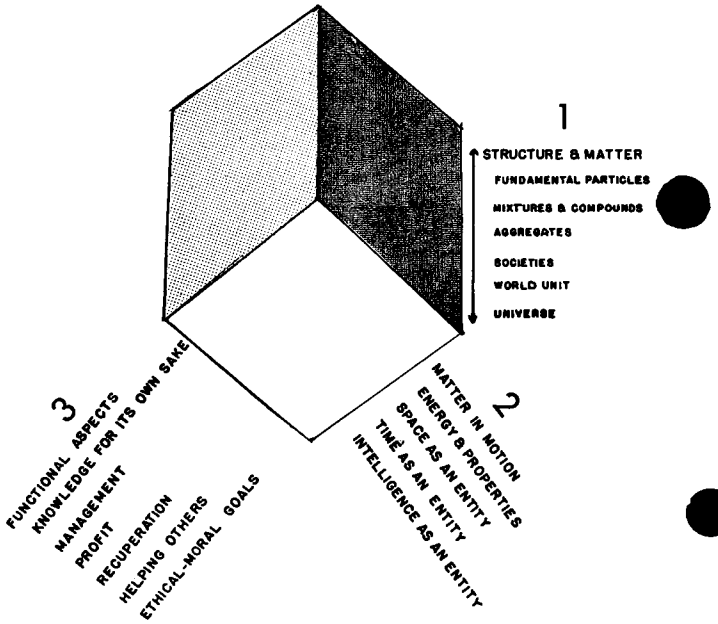
Our third dimension, or viewpoint, of this whole subject centers definitely about man. It deals with the functional aspects of understanding matter, broadly interpreted. It provides man with a purpose, or purposes, for understanding the previously suggested dimensions. These purposes vary from simply mastering knowledge for knowledge's sake, to using it for personal advantage, to using it to help others, and to using it to make a better world in which to live. Most of the types of human activity should find some recognition in the proposed areas of consideration.



Education offers professionally some of the greatest possible rewards of life, but, like other rewarding occupations, it calls for a willingness to make sacrifices, to live an unselfish life, and to devote every effort to continuous growth and improvement.

Our fourth dimension might be set up on the following plan:

4th Dimension. The Growing Individual in His Environment



The Developing Individual
- Pre-school Experience
- Genetic Heritage
- Home Experience

School Experience
- Extra-curricular Experience
- Elementary School
- Secondary School

Higher Education
- Vocational School
- College and University

Post-school Experience

Possibly our graph or diagram suggests adequately the idea that at any age the individual human being may make some use of the ideas suggested in the earlier three dimensions, and that, so long as growth continues, life will have an expanding significance. In old age and senility, with the loss of the use of some of the senses, and with the loss of other abilities, there obviously comes a contraction.

Throughout the growth of the individual, from youth to old age, the teacher finds an opportunity for service. Possibly the joy of service in this field was best expressed by a former student of mine, Eleanor Johnson Bogan:

It may be I shall never pass
Down some queer, vivid foreign street.
Nor hear the temple gongs of beaten brass
Above the heavy tread of many feet.
Yet shall I be content with only this:
With every gentle, soft-returning spring
Down crooked lanes where tiny leaves unfold,
To go adventuring.
It may be I shall never see
A Chinese junk with purple sail,
Drifting upon a quiet, greenish sea,
Drifting beneath a sunset, cold and pale.
Yet shall I be content with only this:
To feel a little child clasping my hand,
To go adventuring in that child's heart,—
Some day, to understand.