Abstracts of Papers Presented at the AAAS Centennial Celebration[1]

GENES AND CYTOPLASM

Genes as Determiners of Cellular Biochemistry

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The mechanism which enables specific hereditary units (genes) to determine specific heritable characters is the subject of this review. The work discussed centers chiefly around one microorganism, a fungus, the pink bread mold, *Neurospora crassa*. This organism was selected for discussion since it affords at the present time the best material with which to correlate genic and biochemical changes.

Following ultraviolet irradiation, strains of this fungus have been isolated which differ from the ordinary strains found in nature by having to be supplied with the vitamin niacin for growth. Genetic investigations have shown that the requirement for niacin of these new strains is a heritable character, and results from the alteration of a single gene of the ordinary wild type strains, *i.e.* a single gene difference exists between the strains requiring niacin and the strains found in nature. A single gene determines, therefore, whether a given strain of this fungus can synthesize niacin. Biochemical investigations reveal that the inability of such strains to synthesize niacin results from the fact that these strains have lost the ability to carry out a single specific biochemical reaction. Thus, alteration of this single specific gene has resulted in the loss of a single specific biochemical reaction. Similar investigations of many other genes have invariably led to the same conclusion, *i.e.* that single genes control single biochemical reactions.

How do genes control biochemical reactions? Nearly every biochemical reaction that occurs in a cell requires the presence of a particular type of organic substance to enable the reaction to proceed. Such organic substances are catalysts called enzymes, and specific enzymes are associated with specific reactions. Since enzymes and genes are both chemically proteins, an attractive and plausible theory has developed, stating that genes exert their control of biochemical reactions by determining the specificity of enzymes, *i.e.* that the gene determines what reaction the enzyme can catalyze. Direct proof of this theory, however, is still lacking. Recent work in this field has demonstrated that loss of specific genes is associated with the loss of specific enzymes. The direct demonstration, however, of a gene alteration giving rise to enzyme alteration has not yet been carried out.

Current views regarding gene-enzyme relationship might, therefore, be summarized as follows: Single genes control specific biochemical reactions, and it is thought that this control is exerted through the determination of enzyme specificity. Stated another way, single genes determine the specificity of single enzymes. The mechanism whereby genes control enzyme specificity is still a major biological enigma.

How does such a theory relate to heritable traits in higher organisms such as man? The genetic control of biochemical reactions applies equally well to all organisms and has been demonstrated in a great many, including man. Biochemical differences appear not only as differences in growth-factor requirements for microorganisms, but as morphological differences such as skin color in man as well. All such traits are genetically controlled. In fact, there is little reason to suppose that the mechanism of gene action in microorganisms such as bacteria and fungi is substantially different from that of macroorganisms such as insects, higher plants, and mammals, including man. (Complete paper to be published in *Science*.)

The Effects of Changes in Quantity, Combination, and Position of Genes

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Genes are submicroscopic reagents. They come in pairs, since of any kind of genes the father and the mother each contribute one representative. If genes are large molecules, as assumed in general, a fertilized egg cell contains just two molecules of each genic kind.

Each genic species may occur in one or more varieties. It may make all the difference in the development of an individual whether the two molecules are of one variety or of the other: one will lead to an individual with full mental faculties, another to an imbecile; or one to a person with normal hands, another to one with hands having 7 fingers. That this pair of single gene molecules accomplishes such far-reaching consequences is one of the riddles of "gene physiology."

While we know that there *are* genes, we lack knowledge of their exact make-up. If we knew their chemical structure and could study the materials in the cell with which they react, we could unravel the threads which lead from the gene molecule to the external character. Lacking this knowledge, we still can study some aspects of our problem. For instance, in favorable cases we can vary the quantity of a gene. Instead of two genes, a cell can be made to have only one or three genes. Will it make a difference in the outcome if an egg starts development with one, two, or three doses of a gene? Or, what happens if the two genes of a kind belong to slightly different varieties? Will their joint effect be more or

[1] In the absence of an abstract, title and author's name are listed.

less or the same, as compared with the effect of one variety alone? Still another question: Genes are located at specific spots at specific chromosomes of the cell nucleus; if we artificially change the location, by shifting the genes to new chromosomal places or by shifting and replacing some of the chromosomal material near to them, will the genes now cause different effects?

Experiments which should help to answer such questions were performed with the fruitfly, *Drosophila*. The gene study affected the length of a certain vein on the fly's wings. Measuring the length of this vein in flies which started out with different quantities of the gene, different combinations of its varieties, or different positions of the gene, provided a method akin to the chemist's titration procedures of evaluating the effects of the different genetic conditions.

The results indicate that increasing the number of gene molecules results in increase of gene effect. This means that the cellular material with which the genes interact is not exhausted by the action of one or two doses of gene but is present in excess. It is further found that a gene variety which causes partial lack of vein (in contrast to a gene variety which leads to presence of a full vein) makes for more vein if the gene is increased in quantity. In other words, it is not a gene for lack of vein but rather a gene for production of some, but not sufficient, vein material. Another finding arose from the study of the effect of combinations of gene varieties. It turns out that two different varieties of a gene interfere with each other's activities. Their joint action may be less than that of either one alone. Finally, shifting the position of the gene will change its effect, many different positions being responsible for many different actions.

Someday the biochemists will discover the underlying details of these processes. In the meantime the manipulation of gene quantities, combinations, and position gives us insight into the small-scale processes in the cell and its nucleus which are responsible for the course of development. (Complete paper to be published in *Science*.)

Genes and Cytoplasm in Cellular Heredity

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The cells of which organisms are composed consist of a nucleus, with its genes and chromosomes that control Mendelian heredity, and of cytoplasm. It is well known that the cytoplasm protects the genes, nourishes them, is the site of activity of their products, and manifests the results of their activity. May the cytoplasm also play a part, comparable to that of the genes, in controlling heredity traits?

The existence of hereditary differences among genically identical cells and organisms is demonstrated by a number of examples in microorganisms, higher plants, and higher animals. In these examples the hereditary differences are cytoplasmically controlled. Though often ignored, this should be recognized as one of the capital facts of biology. What is the physical basis of this fact? How does the cytoplasm exert its determinative action? In a few cases the physical basis lies in visible self-multiplying cytoplasmic bodies. The most significant fact in the remaining cases, nearly all of which seem superficially to be independent of the genes, emerges from a study of the inheritance of specific substances in *Paramecium*. Here the genes of each individual control a series of alternative potentialities, and the cytoplasm controls which of the potentialities will materialize and be transmitted to the progeny.

Three hypotheses for interpreting these results are discussed: (1) the variable gene activity hypothesis—the activity of a gene varies directly with the cellular concentration of its cytoplasmic product; (2) the hypothesis of alternative steady states—high cellular concentration of the direct or indirect product of one gene inhibits the reactions leading to products of another gene and vice versa; (3) the plasmagene hypothesis—the genes control the production in the cytoplasm of self-multiplying materials that form a competitive system. The first hypothesis is held to be insufficient, but the other two are both formally acceptable. Points for and against these two are discussed, and decisive tests of them are proposed.

Regardless of what hypothesis of cytoplasmic control turns out to be correct, the primary fact remains established: the control of hereditary cellular traits is in these cases cytoplasmic and self-perpetuating. The cytoplasm, as well as the genes, plays a decisive role in determining hereditary traits.

HIGH POLYMERS

Structure and Behavior of Rubberlike Substances

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The other papers of this symposium deal with dilute solutions of high-polymer molecules; this paper deals, instead, with rubber-like substances which are made up entirely of these molecules.

Rubber is prepared from liquid polyisoprene ("milled rubber") by vulcanization, a process which introduces a relatively few chemical bonds between the polyisoprene molecules. These bonds unite the long, flexible molecules into a flexible but coherent network without otherwise modifying much the liquid-like structure of the material; this is why rubber is easily deformed, without being easily pulled apart.

The useful properties of rubber do not depend on its special composition, but only on its being a strong and flexible network of molecular chains with a freezing point below ordinary temperatures. Knowing this, the rubber chemist knows in a general way how to proceed in producing a new synthetic rubber. He must start with, or arrange for the production of, long flexible molecules. He must choose molecules which do not exert large forces on each other; otherwise, he will get a glassy or hard plastic. He must make sure that the molecular chains are not too easily packed together into crystals; otherwise, he will get a rigid crystalline solid. Finally, he must arrange for the linking together of these molecules at enough, but not too many, points; otherwise, he will get a viscous liquid or a brittle substance like the ''hard rubber'' of telephone mouthpieces.

To make it possible to predict how one can prepare a rubber-like material with desired special properties, it is important to gain a more detailed understanding of how the curious and complex behavior of these materials depends on their structure. This paper deals mainly with the explanation of the elastic properties of rubber, and with new ideas concerning the crystallization or freezing of rubber.

The elastic properties of rubber-like materials are much like those of gases, both in character and in origin. The pull of a piece of stretched rubber is due to the jerking of the molecular chains in it; these, like the molecules of a gas, are in constant motion. An increase in the temperature increases the violence of this jerking, and thus the tension in the rubber. The variation of this tension with stretch and temperature can be predicted theoretically for rubbers of especially simple (''ideal'') structure and follows a simple law. Soft rubbers in general deviate little from this ideal behavior when they are not stretched too violently. Large deviations occur, however, when the rubber is frozen by violent stretching.

The freezing of rubber differs greatly from that of ordinary liquids. It has no definite freezing point, but freezes slowly over a wide range of temperature. Natural rubber is most readily frozen by stretching it violently; this raises its melting point to above the boiling point of water. The properties of frozen rubber depend in a surprising way on the temperature or extension at which it is frozen and on how long it is kept frozen. It will be shown how this behavior can be completely explained in terms of the known structure of rubber. ''Supercooling'' plays an important role in this behavior; so does the fact that the rubber molecules in a crystal are not all essentially identical (like the water molecules in an ice crystal) but are permanently distinguished from each other by their positions in the molecular network in the rubber. (Complete paper to be published in *Science*.)

Polyelectrolytes

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Polyelectrolytes are substances of high molecular weight which are simultaneously electrolytes. Synthetic materials of high molecular weight have become fairly familiar to the general public, thanks to the wartime synthetic rubber program and to the interest in synthetic textiles such as Nylon. Electrolytes are defined as compounds which will carry an electric current in solution; well-known examples are the sodium chloride (common salt) in sea water and the sulfuric acid in the storage battery. A number of naturally-occurring substances, such as proteins and polysaccharides, are known to have high molecular weight and are electrolytes as well. Their structure is rather complicated and has not yet been fully investigated. Furthermore, their electrical and hydrodynamic properties are quite unlike those of simple electrolytes. The properties of electrically neutral polymers and of simple electrolytes are well understood, in the sense that we have a molecular model which can be used to predict their properties in terms of fundamental parameters. It therefore seemed logical to synthesize linear polymers of known structure, convert these to electrolytes, and then study the properties of the products. In this way we may obtain at least an empirical correlation between structure and properties and eventually, by analogy, draw some conclusions concerning the biologically important natural polyelectrolytes.

Just as synthetic rubbers can be made which have properties not shared by natural rubber, we can make polyelectrolytes unlike those which appear in nature; in other words, we can start with rather simple structures and gradually increase their complexity. For example, weak electrolytes *i.e.* those which are only partially dissociated into ions which are free to carry the electric current are more complicated in their behavior than the strong electrolytes, which are completely dissociated at low concentrations. The natural polyelectrolytes are nearly all weak electrolytes so the attendant problems are added to those of unknown structure. Our initial program therefore consisted in the synthesis of long-chain *strong* electrolytes and a study of their properties.

Vinylpyridine is a substance much like styrene (vinyl benzene), one of the ingredients of synthetic rubber, with the significant difference that it contains a pyridine ring instead of a benzene ring. The vinyl group still will build the monomer into long chains, exactly as with styrene. After polymerization, the neutral nitrogen atoms in the pyridine rings in the polymer are converted into ionic nitrogens by the addition of alkyl halides such as butyl bromide. In this way, a long-chain strong electrolyte is obtained. By copolymerizing the vinylpyridine with styrene, other electrolytes with different (but known) distributions of charges can be made. Other methods of making synthetic polyelectrolytes have also been developed, but this example should suffice. Then the conductance and viscosities of solutions of these compounds at different concentrations and in different solvents have been measured. Just like polysaccharides from pneumococcus, these solutions have very high viscosities which are depressed by the addition of simple electrolytes like sodium chloride. The conductance data give a measure of the relative number of free ions and have shown that the intense electrical fields produced by concentrating many ions into the small volume occupied by the chain molecule lead to properties which resemble those of highly concentrated solutions, even when the polyelectrolyte is present in dilute solution. (The full article on which this abstract is based appeared in *Science*, 1948, **108**, 545–550.)

Structure of Polymers in Solution

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The first and most elementary question to be asked about a polymer in solution is that about its molecular weight, and this question is answered at once by any experimental method which enables us to count the number of independent polymer particles distributed throughout the solvent. The classical method is a determination of the osmotic pressure, and this easily gives the desired result, fundamentally because at a given temperature all particles, no matter how different their structure may be, have the same translational energy. However, the higher the molecular weight, the smaller is the number of individual particles in a given weight and the smaller is the observable osmotic pressure. Apart from the experimental difficulties connected with any experiments on osmotic pressure, this was the reason why I thought it advisable to see whether a better method, especially adapted to the heavy particles generally encountered in the polymer field, could not be found.

During the war years and in connection with the Rubber Reserve Program such a method, which becomes easier to handle with increasing molecular weight, has been developed; it consists in measuring the intensity of the light scattered by the solution as compared to the intensity of the primary beam which passes through the liquid. In dilute enough solutions the scattered intensity is, of course, proportional to the number of particles, which is what we want to measure. However, nothing analogous to the simple equipartition law mentioned in connection with the osmotic pressure exists in this case concerning the light intensity. Whether a simple particle scatters more or less depends very much on its structure. But it can be shown that all we need to know in order to make our counting effective can be derived from an additional measurement of the difference in refractivity of solution and solvent. As a rule, to be sure, neither this difference in refractive index nor the turbidity is large. One unit in the third decimal of the refractive index and a turbidity equivalent to a loss of 1/mil in intensity of the primary beam/cm is the order of magnitude in customary polymer solutions at 1% concentration. But both these effects can easily be measured with satisfactory precision. Recently, in collaboration with R. H. Ewart, of the U. S. Rubber Laboratories, it could be shown that turbidity measurements can also be used to give information about the extent of preferential adsorption by the polymer in mixed solvents.

A coiling straight-chain polymer of higher molecular weight occupies rather a large space in a solvent. Even if we believe for the moment in absolutely free rotation around bonds and no mutual interaction of the parts of the chain, the spherical space occupied on the average by a polystyrene molecule of 1,000,000 molecular weight can be calculated to have a diameter of 300 Angström units. This is already 1/10 of the wave length in the liquid of the light usually employed in measuring light scattering. In such a case appreciable differences in phase must exist between the rays of scattered light coming from different parts of the same molecule, and this should lead to interference effects fundamentally of the same character as those observed in X-ray or electron scattering by single molecules of low molecular weight. As a matter of fact, it is observed that solutions of such heavy-weight polymer particles scatter more light in the forward direction (direction of propagation of the primary beam) than backward. It is only necessary to compare the two scattered intensities in directions making angles of, say, 45° and 135° with the direction of the primary light in order to measure directly the size of the polymer molecule in solution. Such measurements reveal that this size generally is a good deal larger than expected from current estimates based on free rotation around bonds and missing interaction between parts of the chain. So, in this way we arrive at an estimate of the actual chain stiffness.

Intimately connected with the angular dissymmetry effect is the appearance of an anomalous dependence of the intensity of the scattered light on the wave length, which for very small particles (the normal case) obeys Rayleigh's law, being proportional to the reciprocal 4th power of the wave length. For this reason another method for measuring sizes can be based on observations of the dependence of the scattered intensity on the color of the primary light. This method can be handled most easily, especially for relatively large particles.

Addition of a small amount of a coiling polymer to a large volume of a solvent gives a large increase of viscosity. Thinking of the large-size chain molecules involved which link very distant parts of the solvent with each other makes the qualitative explanation of this effect obvious. Since Staudinger, the viscosity increase measured by the intrinsic viscosity (the relative increase of viscosity per concentration unit) has been used extensively in order to obtain estimates of the molecular weight. The intrinsic viscosity is not, as first supposed by Staudinger, proportional to the molecular weight. According to a suggestion of Mark, it can usually be represented over a large range of molecular weights as proportional to a power-function of the molecular weight, mostly with an exponent somewhere between 1 and $\frac{1}{2}$. Since neither the proportionality factor nor the exponent can be derived from any other measurements than those on the viscosity of solutions of the same kind of polymers of known molecular weights determined in some other way, it cannot be called a method for the determination of molecular weights. On the other hand, viscosity measurements are very easy to make, and, provided the experimental results can be properly understood, they should reveal some probably interesting features of the polymer structure. The actual motion of a polymer molecule and its parts in a liquid flowing as it does in some experimental arrangement used for measuring viscosities can be analyzed. In this way it can be shown that the intrinsic viscosity should be proportional to the average square of the distance of the average monomer group of the chain from the center of gravity of the whole molecule. But this average square of the distance is proportional to the number of chain links and therefore to the molecular weight. So it seems that, after all, theory leads to Staudinger's rule. However, a more thorough inspection of this theory reveals that in its development it is assumed that the molecule does not disturb the motion of the surrounding liquid in the least. Recently it has been possible to take account of this disturbance by a method which can be handled mathematically. In this way it appears as important that the molecule, as a result of the disturbance originating with each of the individual monomer groups, shields its interior parts nearer its center of gravity, more or less from the effects of the liquid flow at its outside. This shielding effect can be measured by a shielding length characteristic for the distance over which the outside velocity distribution makes its influence felt into the interior of the space occupied by the polymer molecule. Discussed along these lines the intrinsic viscosity becomes equal to the specific volume, or the equivalent reciprocal of the density with which the polymer molecule fills the average space it occupies in the liquid, multiplied by a correction factor which depends solely on the shielding ratio defined as the quotient of the radius of this space to the shielding length. With respect to the dependence of the intrinsic viscosity on molecular weight, it follows that for linear chain molecules it should be proportional to the molecular weight itself for small values and gradually, with increasing length of the chain, change to proportionality with the square root as the limiting law for very long chains. Mark's rule appears as an approximation adapted to the range of molecular weights under investigation, and its exponent is a measure for the shielding ratio prevalent in this range. In this way experiments on viscosity lead again to a determination of the size of the polymer molecule, and the comparison of intrinsic viscosities in different solvents has already shown in a quantitative way how the chain polymer coils up tighter with decreasing solvent power of the liquid. It will be interesting, in the near future, to confront size determinations from viscosity with those derived from the dissymmetry of light-scattering. (Complete paper to be published in *Science*.)

HOUSING

Housing in the Redevelopment of American Cities

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For many reasons, housing has proved to be a difficult subject both for the formation of public policy and for research. Among these reasons is the fact that the term has several differing meanings. In one sense housing is the methods, practices, and policies under which houses are produced, maintained, owned, and used. A house, of course, may be looked upon as a structure, as a structure plus equipment, as a structure plus equipment plus the services provided by local government and other agencies.

As a matter of realistic fact, American families live not only in houses but in neighborhoods, in cities, and in metropolitan regions of which the individual cities are component parts. If we take the end objective of housing to be a decent environment for individual and family life, the neighborhood, the city, and the metropolitan region deserve our attention as much as the house structure and its equipment.

This paper outlines some of what I take to be the basic facts, problems, and research needs with respect to the neighborhood and the metropolitan region.

Two outstanding facts should be recognized at the outset:

(1) We have less reliable information and agreed-upon opinion with respect to neighborhoods and metropolitan regions than we have on houses and their equipment.

(2) Many metropolitan regions, in which about 50% of our total population now lives, show alarming signs of disintegration and decay. In large parts of the metropolitan areas, the neighborhood has all but disappeared. Blighted areas of different kinds are found in nearly all such regions. Every indication is that they are growing from year to year—some at a very rapid rate. If the American people are to have housing of the kind they have a right to expect from an economy as advanced and productive as ours, we must learn more about this process of disintegration and what can be done to overcome it.

During recent years several proposals have been made that would enable public or private agencies to acquire sizable blighted areas, clear them, and make them available for redevelopment. A few of these plans are now being tested on a small scale with funds provided by state and local governments. Undoubtedly we shall see, during the next 15 or 20 years, much more interest and activity of this kind. If this work, however, is to be wisely and effectively done, we must learn more than we now know about the organization and economy of metropolitan areas. Surgery on the blighted districts should not proceed without knowledge of the history of the patient and a reasonably complete diagnosis of the ills of which the blighted districts are themselves the most painful symptoms. I suggest that we need analysis, research, and discussion in at least 5 subareas or fields:

(1) *The metropolitan region as a complex plant in which the business, industry, and day-to-day life of its citizens are carried on.* What are the relative advantages and disadvantages of centralized development *vs.* open development? What are the real costs of congestion? How do urban structure and density affect the costs of municipal services, the loss of time and energy in travel, the expenses of conducting business and industrial operations? Would we be better off if our large metropolitan areas were built up in a number of medium-sized satellite towns rather than as a more or less continuous develop-

ment? In an age of atomic and biological warfare, what effects should defense and security considerations have upon desirable urban patterns?

(2) *The city as a place to live.* Is the decline of urban neighborhoods inevitable? Do city dwellers want the kind of life that real neighborhoods make possible? Are we evolving a substitute for neighborhood units that are better suited to life in these times? Does the spread of suburban towns throw any light on these questions?

(3) *Government organization in metropolitan areas.* To what extent are the blight and disintegration of districts within metropolitan regions due to the disorganization of government services and facilities? What steps seem feasible to help correct this condition?

(4) *The planning function in metropolitan regions.* City planning is now recognized as a necessary and desirable function, but it is still weak and ineffective in many respects. How can it be improved and applied to the trends and problems of the larger metropolitan districts?

(5) *Local tax systems.* To what extent do the present systems of local taxation contribute to blight and disintegration? What have we to learn from recent experiments with newer forms of local revenue?

In this broad field of metropolitan economy and life, questions are much more apparent than reasonable answers or solutions. To ask the right questions, however, is certainly the first step. After them must come hypotheses concerning the basic relations and then tests and reformulation of these hypotheses.

I do not suggest that research in these phases of urban redevelopment should prevent us from pressing forward on other housing fronts. I do suggest, however, that we will never fully understand the housing problems of this country or be in a position to outline effective housing policies until we give much more attention and study than we have so far to these broader problems of urban neighborhoods and metropolitan areas.

The Contribution of Science to Housing

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In spite of the fact that science and engineering have developed principles, techniques, and materials for the mass production of comfortable and hygienic homes, our present low standards of housing constitute one of the most acute problems with which this Nation has ever been faced.

If we conceive of the pattern of American living in terms of well-planned communities and well-built homes, we must begin at once to apply the findings of science to our problem.

A wider understanding by the public of the contributions which science can make to housing is essential. As a result of this understanding, local building codes can be unified and modernized to take advantage of newly developed materials, and restrictive labor practices can be eliminated to utilize newly developed techniques.

A central agency to correlate the findings of science and to give these findings the broadest dissemination is a necessary first step toward meeting the crisis. Other necessary steps are soundly financed, government-aided housing for the lowest-income groups and a great amount of self-supporting public housing for our large middle-income group. Although we cannot now afford a large-scale slum clearance program, we must ultimately, for our own national health and welfare, eliminate all slums and blighted areas.

Housing: Where the Natural and Social Sciences Meet

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Until very recently the natural and the social sciences have developed more or less separately. There has even been a moderate degree of rivalry between them for the approbation of the public. In this rivalry the natural sciences are obviously far ahead of the social sciences, and yet we realize more and more that the solutions of the great problems now confronting the world must be discovered in the realm of human relationships rather than in that of the natural sciences. Furthermore, with the increasing integration of the world it is clear that the natural and the social sciences depend very much upon one another. Hence, they must, for their own sakes alone, as well as for the service of mankind, meet on good, common ground and work together. Such a common ground is the housing problem, now so acute throughout America and the world.

The housing problem and its corollary, town planning, require the closest cooperation of all the sciences. On its face this problem will inevitably seem to be more of a social problem than a scientific one. In that respect, however, it does not differ greatly from most of the paramount issues now confronting mankind. Hence, it ought to be possible to effect a good division of responsibilities between the two great branches of science, and at the same time such a degree of direct cooperation between both natural and social scientists as will enable social scientists to learn from the natural ones a more perfect scientific method and natural scientists to learn from the social ones greater concern for the kind of world in which mankind has now to live.

It would seem to be the primary obligation of the social sciences to provide the necessary data on the people who are to be provided with housing, the different kinds of housing that people of different incomes can afford, and want, and need. These matters greatly affect the design of any house or apartment building, and at this stage the natural scientist enters the picture to provide solutions for very concrete problems relating to types of materials, substitute materials, materials of different cost and quality, and the basic standards on which all housing must be built and maintained to remain standard and fit for human habitation. The natural scientists are indispensable and have a primary responsibility in all biological and technical matters. But in the field of housing they cannot make their best contributions by working alone and on small, isolated scientific problems. What is needed is a national housing research agency, very broad in scope, which will team the natural scientists with the social scientists in a progressive and evolutionary study of housing problems.

HUMAN INDIVIDUALITY

Primary Mental Abilities

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Until rather recently it was customary to appraise the mental endowment of children and adults by psychological tests that gave a single index of intelligence, such as the mental age or the intelligence quotient. These indices were very useful in estimating the mental endowment of school children. The serious limitation of the I.Q. as an estimate of mental endowment is that two men may have the same I.Q. and yet be totally different in the mental abilities that they possess. The fundamental problem in this field is, therefore, to isolate and to describe the distinct mental abilities which constitute mental endowment.

During the past 20 years the multiple-factor methods have been developed as new scientific methods especially for the solution of this problem. In the experimental and analytical work with the factorial methods a number of the basic or primary mental abilities have been isolated. The tendency now is to describe an individual's intelligence in terms of a profile that shows his rating in each of the distinct mental abilities. The mental profile is much more useful than any single index in describing the abilities of each person.

Following is a brief description of some of the primary abilities that have been isolated so far.

There are several distinct mental abilities that are associated with the visualization of objects in space. One of these is the space factor S. Most people who are intelligent are fairly well endowed with this factor, but there are many highly intelligent people who are conspicuously poor in this primary ability. Most scientists are good visualizers. It has been found that the ability to handle numerical work is a primary factor which has been denoted N. A cashier would soon quit his job if he were poor in the number factor. One of the socially most important primary mental abilities is verbal comprehension V. It is represented rather well by tests of vocabulary. Another verbal factor is word fluency W. It is quite distinct from the verbal factor V. A person can have a high score in verbal comprehension indicating a capacity for profound verbal reasoning and yet have a low score in word fluency. Another person may be very fluent although he has a limited vocabulary.

It has been found that the ability to memorize is a primary factor quite independent of the other mental abilities. One of the most interesting is the mental ability that enables one to discover the rule or principle in the material with which one is working. This ability has been called induction. It is not yet known whether it is associated with originality or creativeness.

In the field of perception several basic or primary abilities have been isolated. One of these is speed of perception. It has been found, for example, that inspectors in some types of work are more efficient if they possess the factor perceptual speed. Other perceptual factors have been called visual and auditory acuity. For example, two individuals may have the same degree of hearing difficulty as determined by acuity tests; one of them may succeed fairly well in understanding what people say, whereas the other has trouble in understanding what he does hear. The difference is caused by the closure factor that enables one person to fuse what he does hear into meaningful speech where the other person fails in this regard.

Experiments at different age levels have revealed essentially the same primary mental abilities. The experiments included groups of college students, high school students, eighth-grade children, and finally, kindergarten children. Some primary mental abilities can be estimated in young children even before they have learned to read. Experiments are under way to determine whether teaching methods should be adjusted to fit the mental profile of the children.

A one-year curriculum has been prepared for training the mental abilities of kindergarten children. It consists of a new game each day, the games being designed to train young children in space and perception, verbal comprehension, and inductive reasoning. Young children of this age are better in reasoning than we ordinarily believe. Adults carry out most of their reasoning in the verbal medium, which is not well developed in young children. It has been found that the mental profile has a close relation to the ways in which an individual tries to solve his personal and emotional problems. The central idea in this work is that human intellect consists of a large number of distinct mental abilities that are called primary factors. Each individual is described in terms of a mental profile instead of by a single index such as the I.Q.

The Individual and the Culture Process

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A conception of the individual as a prime mover, the source and basis of human behavior, is widely held in cultural anthropology and related sciences today. A corollary of this proposition is that, since the individual is the determinant of sociocultural phenomena, these must be explained in terms of the individual.

Thus, various anthropologists have asserted that every element of culture has been created by the individual, that culture is nothing more than the responses of society's individual members, and therefore the individual is the logical starting point for any investigation of sociocultural phenomena. We find these propositions unsound.

We grant, of course, that culture is dependent upon the human species and could not exist without it. It is obvious also that the human species is composed of discrete biological entities which we call individuals. It is apparent, therefore, that culture finds its expression in the behavior of individual human organisms. But it does not follow that the culture process can be explained by invoking the individual as a prime mover, as an innovator or determinant. On the contrary, we would take the position that the individual is irrelevant to an explanation of the culture process.

Culture is an organization of beliefs, customs, tools, utensils, etc. that is dependent upon the ability, unique in man, to use symbols. It is a continuum, a cumulative tradition, passed down from one generation to another. Everyone is born into a cultural tradition that embraces him at birth and equips him with beliefs, attitudes, customs, tools, etc. *Human* behavior, as distinguished from *primate* behavior, is the response of an organism of the species *Homo sapiens* to a cultural tradition. It is culture, not the human organism, that determines such differences of behavior as that between Chinese and Swedish, or the difference between the behavior of the English people of A.D. 1000 and of A.D. 1900.

Culture as such is not explainable in terms of individual psychology; in fact, it is not explainable in terms of psychology at all. Culture *as culture* can only be explained in terms of culture, *i.e.* culturologically. Culture is a stream of elements that are continually interacting with one another, forming new combinations and syntheses, eliminating some elements from the stream, and incorporating new ones. This stream, this culture process, has its own principles and its own laws of change and development. Just as the linguistic process is explained philologically, so the culture process in general is explained culturologically rather than psychologically.

Human organisms are, of course, essential to the existence of the culture process. But culture cannot be explained in terms of these organisms. We can, however, explain the behavior of the individual in terms of the culture that embraces him. In the culture process the individual acts as a catalytic agent, making the interactive process possible and continuous. But from the standpoint of an interpretation of the culture process, the individual is merely the locus of its existence and the medium of its expression, not its creator or determinant.

The Genetic Approach to Human Individuality

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No two human individuals are exactly alike. Yet all human beings possess certain traits in common. The similarities and differences observable and measurable among people are the results of the interaction of genetic and environmental influences. Modern genetic methods are successfully distinguishing between the relative contributions of these interacting influences, and indicate that the proportionate extent of these contributions differs from trait to trait. Significant genetic components are known to many traits—among them, the hemagglutinogens, which in various combinations form the 2,000,000 blood groups; the enzyme systems involved in metabolism; the taste deficiencies; anomalies of the eyes, muscles, nerves, glands, blood, skin, hair, teeth, nails, and other body organs and systems.

Genetic analysis of human beings is made through two main channels: Mendelian genetics and population genetics. The principles of both must be understood and used in order to understand human individuality. Among the findings emerging from the study of population genetics is the conclusion that human populations differ genetically one from the other almost entirely in the varying *proportions* of the alleles of the various sets and not in the *kinds* of alleles they contain.

The manifold combinations of traits which in turn derive from manifold combinations of genetic and environmental influences result in the almost infinitely diverse range of human individuality—a range which we are just beginning to comprehend.

WORLD'S NATURAL RESOURCES

The Exploitation of Mineral Resources

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The efficiency and adaptability of an industrial civilization are dependent on minerals as well as on men; the search for minerals and the exploitation of rich deposits were vital factors in world power in the time of Alexander the Great; they are increasingly crucial today.

Minerals are finite, expendable resources which year by year become more expensive to discover and to exploit. The geology of a region predetermines the kind and quality of mineral resources locally available, and no industrial country has within its borders adequate supplies of all the minerals essential to its economy. The world's known supply of several strategically important minerals is localized in a very few widely separated areas.

Mineral exploitation in many countries has shown a common pattern: flush production of cheaply produced minerals at an early stage, attended by quick wealth and power, is followed by declining output, acquisition of foreign sources of ore, and appreciable imports; later, as domestic mineral production becomes increasingly expensive and mineral imports contribute more and more to industry, the economic advantage of cheap raw materials is lost, and social, economic, and cultural strains result. Great Britain passed its peak in the production of lead, copper, tin, iron, and coal between 1856 and 1913 but at times was the world's largest producer of these products. The United States has passed its peak for mercury, lead, and possibly a few other metals but has reserves of iron, coal, phosphate rock, and molybdenum ore that should meet all demands for generations, and the supplies of copper, zinc, aluminum, gold, and petroleum should be adequate for another 20 years. Known reserves of lead, manganese, and vanadium ore would hardly last a decade at present consumption levels unless supplemented with substantial imports. Domestic deposits of platinum, antimony, mercury, tungsten, chromium, nickel, tin, mica, graphite, asbestos, diamonds, and quartz crystal are negligible, and these commodities must be largely imported.

The Soviet Union probably has not yet reached peak production in any of its important mineral resources, but like other industrial nations, it has an ever-growing concern for the position, extent, and availability of mineral deposits at home and abroad.

To avoid industrial or military conflict over the scattered major foreign sources of cheap raw materials several steps should be taken to lessen the industrial dependence on imports of the strategic minerals. Substitutes should be sought among combinations of metals that are readily available; metallurgical research must anticipate future shortages years before they arise. Similarly, preparations should be made now to exploit low-grade, currently noncommercial deposits in the most efficient way when their more expensive contribution is finally necessary.

Discovery of mineral deposits is still an art rather than a science; much fundamental chemical and physical research in suitable laboratories will be required before either oil or mining geology has a sound scientific basis. Thanks to the field geologist, our empirical knowledge of geologic relations is increasing steadily, and this is at present our chief hope of improving discovery rate. Geophysical and geochemical field methods have been very helpful in many places, but their scope is still relatively limited. Research directed toward discovery of hidden deposits is urgently needed; it should be carried on in field and laboratory by cooperating groups of physicists, chemists, and geologists, and the validity of conclusions reached should then be checked. Beyond such research however, we desperately need wise planning for economic and equitable utilization of the world's widely scattered deposits. To this end geologic work, exploration, and reserve estimates should be accelerated in all countries so that an inventory will be at hand for use by the next generation in planning those global economic units that will most effectively utilize our planet's resources to the maximum benefit of all mankind. (Complete paper to be published in *The Scientific Monthly.*)

On Living in the Biosphere

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The region of the earth which can be inhabited is called the biosphere. It is suitable for life because of its temperature, its composition, and its continually received supply of radiation from the sun.

Processes that occur in the biosphere which change it permanently are called *acyclic*; those not changing it, *cyclic.*

The effect of man on the cycles of carbon and phosphorus is examined. Most of man's activities tend to make processes less cyclic and so change the biosphere, making it less suitable for life. We have reached a point in this process when human assets are the only thing that we have in abundance. Any future economy of abundance must be based on human ingenuity rather than on abundance of raw materials. The main obstacles to such a development are fear of war and a wrong orientation on the part of the public toward natural resources. Exploration of our culture with a view to finding forces working in favor of a more constructive attitude is essential. An example from the advertising field is discussed. (The full article on which this abstract is based appeared in *The Scientific Monthly,* 1948, 67, 393.)

Plants and Vegetation as Exhaustible Resources

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It is the thesis of this address that much of man's basic needs for food, clothing, and shelter—with which his economy has always been concerned—are directly or ultimately of plant origin, and that these natural resources are not quantitatively adequate to permit a continuing consumption at present world rates, with the result that men everywhere must face squarely the dual problems of the conservation of natural resources and the limitation of population or continue along the path, with an accelerating rate, toward self-destruction.

The nature of vegetal resources, both as direct products from plants and as vegetation, is reviewed. Attention is also paid to the growing depletion of the world's resources, especially to the causes of the modern acceleration in resource-capital exhaustion and population increase, and to the sociopolitical effects that accompany the inevitable lowering of the level of living. There are favorable factors in the picture, such as technological production advances, the discovery and invention of substitutes for critical materials, and a growing public awareness of, and attack on, conservation problems. But these advances are far from solving the ultimate dilemma.

The successful education of the people in conservation is dependent to a large degree on their general education in economic and sociopolitical fields, as well as in a comprehension of the more direct problems of natural resources. Such education processes are slow, even in countries with a high percentage of literacy. They seem overwhelmingly complicated in many countries where the rate of natural resource destruction is high or where, through past maladjustments, destruction is most advanced, and where perhaps two-thirds or more of the people cannot read. General education is a concomitant of a high level of living. How can that education come to pass where an abuse of the natural resources is keeping men from reaching a level of living where education about that abuse can be effective? It is the most vicious of chain reactions. We are living at a moment of great, and what seems justifiable, pessimism, and perhaps we too are the victims of a psychological chain reaction. But the dual problems of population control and of our dwindling resources seem to me ones that have even less likelihood of a solution friendly to man than the control of the atomic bomb. (Complete paper to be published in *The Scientific Monthly.*)

INTERACTIONS OF MATTER AND RADIATION

New Properties of the Electron

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Observations on Slow Mesons

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The method of detecting charged particles by means of photographic emulsions has proved to be useful in the study of slow mesons. Since the plates are continuously sensitive, rare phenomena can be recorded over periods of the order of one month. The stopping power is about 2,000 times as great as air, so that it is possible to find large numbers of particles which stop in a unit volume of the emulsion. This property makes the plates useful for the study of relatively rare events such as the stopping of a cosmic-ray meson. This paper describes work at Bristol, England, in detecting mesons from cosmic rays and work at Berkeley in detecting mesons produced by the 184″ cyclotron.

By making use of reactions of light elements, the Bristol group measured ranges of protons of known energies, from which they were able to plot a range-energy curve. From the lengths of the most energetic protons which could be seen in the plates, it was estimated that mesons would be visible up to about 4 Mev in Ilford C.2 plates. Plates exposed for study at Bristol were placed, in their original containers, in the Pyrenees at an altitude of 2,800 m and in the Andes at 5,500 m. Examples of events found, including long proton tracks, stars, "hammer tracks," and events involving mesons are shown. The meson events were found relatively infrequently. Meson tracks are distinguished from tracks of heavier particles by larger scattering and more rapid change in grain density. From the phenomenological point of view there are four types of mesons: (1) ρ-mesons, which slow down and stop uneventfully, without giving any other particles whose tracks are observable in the emulsion; (2) σ-mesons, giving "stars"; (3) π-mesons, giving secondary mesons of constant range and smaller mass; and (4) mesons coming out of stars. An interpretation of the different types, and the relative frequency of occurrence, is given.

A consistent picture can be obtained by assuming that most of the ρ-mesons are positive and negative mesons of the type responsible for the hard component of cosmic rays at sea level. The π- and most of the σ-mesons are of heavier mass and have stronger interaction with the nucleons.

Negative and positive heavy mesons have been observed in the vicinity of the target of the 184″ Berkeley cyclotron. Yields at different bombarding energies are given and mass measurements described. Most of the heavy positive mesons give rise to an observable secondary meson. Approximately 75% of the heavy negative mesons give rise to stars when they come to rest in the emulsion. No secondary mesons are observed to start at points in the emulsion where the heavy negatives stop. The origin of light positive and negative mesons, also observed in plates exposed at Berkeley, is discussed.

How Mesons Disappear

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The mesons which constitute three-fourths of the sea-level cosmic radiation, and which have a mass about 200 times that of the electron, disappear mainly in decay processes in which one electron is emitted.

To take up the recoil in this process there must come off at least one other particle. This particle is not seen and is therefore electrically neutral. Whether one or two neutral particles come off is not known. According as one or two neutral particles emerge there will be a difference in the energy distribution of the electrons given off in a large number of such disintegration processes. The energy spectrum has been calculated on the following three alternative assumptions: (a) one neutral particle of zero rest mass (a neutrino) is emitted; (b) two neutrinos are emitted along with the electron; (c) the electron is accompanied by one neutrino and one neutral meson of rest mass 20–90 times the mass of the electron. The neutral meson in case (c) might or might not be identified with the neutral meson which is known to be given off when a heavy (300-mass) meson gives off a normal (200-mass) meson. The calculated curves are compared with the available experimental evidence to draw conclusions about the nature of the important elementary particle transformation in which a meson decays.

Not all the normal mesons observed at sea level undergo decay. Some of the negatively charged ones interact with atomic nuclei. Preliminary experimental and theoretical evidence makes it reasonable to believe that the meson loses its charge in the process but is not destroyed. The charge transfer converts one of the protons in the nucleus into a neutron and imparts excitation energy to the nucleus. It is possible to understand in this way the nuclear disruptions produced by normal sea-level mesons. Similarly, one can foretell the possibility of a process of meson-induced nuclear fission which has not yet been observed.

SOURCES OF ENERGY

Solar Energy

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The radiation from the sun amounts to about 1 kcal (1 large calorie)/sq ft/min in the temperate zone, or 7,000,000,000 kcal/acre/year. The present and future utilization of this energy is considered. There is apparently enough energy, if used properly, to meet the needs of the human race for food, fuel, and power.

The direct utilization of sunlight for power is difficult because the temperature is too low, but the energy is conveniently converted into the organic material of growing plants, where it can be conveniently stored and burnt with air at high temperatures to operate heat engines. The maximum conversions which can be realized is about 20% of the effective sunlight actually absorbed. Moreover, only about half of the sun's radiation is effective, and in the Temperate Zone the growing season is limited to about a third of the year. The maximum conversion of energy is then limited to about 3.3% in plants grown in the United States. Some of the major agricultural crops utilize a few tenths of 1% of the annual solar radiation which falls on the area in which they are growing. Certain forest trees convert about 0.1% of the sun's radiation into stored energy. The reasons for these comparatively low efficiencies are discussed.

Photosynthesis is a process by which carbon dioxide and water are combined by sunlight in the presence of chlorophyll to give carbohydrates and other organic material. Several significant experimental facts of photosynthesis, including experiments with isotopic tracers, are described briefly, and the present hypothesis for the mechanism of photosynthesis is discussed. The energy of the light is not sufficiently great to cause the direct combination of carbon dioxide and water. Several steps are required, each made possible by the absorption of light by chlorophyll. Hydrogen atoms are probably transferred from the water to the carbon dioxide in a series of chemical reactions. It seems reasonable, then, that about 20% of the sunlight actually absorbed is the maximum that can be stored.

Finally, possible future developments are discussed with reference to the greater utilization of solar energy and the production of more food, fuel, and power. (Complete paper to be published in *Science*.)

Second Thoughts to the Problem of Nuclear Energy

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Atomic energy occupies an intermediate position between our present energy resources, such as coal, gasoline, and the very abundant source of energy which we receive as sunshine. Its great advantage is that the atomic fuel as such has practically no weight. Its principal disadvantage is that dangerous and very penetrating radiations accompany the burning of the atomic fuel. The neutralization of these radiations gives the machinery in which nuclear fuel can be used considerable weight and bulk. The principal effort in the design of atomic machinery is therefore toward making the machinery simple, light, and, at the same time, safe. On the measure of the success of this endeavor depends the fate of the hope that atomic energy may play a real role in our economic life. The outlines of two types of machinery which came to be regarded as conventional are shown.

The great concentration of power in the atomic fuels appears to make them ideally suited for use in transportation. However, the radiation which was mentioned before seems to block their use in vehicles of small size, such as automobiles. They may be more suitable for large ships which have to travel long distances. The use of atomic fuels in airplanes and rockets has not yet been explored sufficiently to venture an opinion. Every industrial use of atomic energy will have to be preceded by more thorough research and more intensive development work than we have so far been able to muster. (The full article on which this abstract is based appears in *Science*, 1948, 108, 517.)

Energy From Fossil Fuels

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It is difficult for those of us living today, especially in the more industrialized areas of the world, to appreciate fully the unique character of the events which we are witnessing. All of our lives, and for the immediately preceding century whose history is most familiar to us, the world has been in a state of continuous change—usually continuous increase. We have seen a few European immigrants into North America expand during a few centuries into a population of over 170,000,000. We have seen villages grow into large cities. We have seen an area of primeval forests and prairies transformed into widespread agricultural developments. We have seen a transition from a handicraft and agrarian culture to one of complex industrialization. In only a few generations we have witnessed the transition from human and animal power to electrical power supernetworks, from the horse and buggy to the airplane.

At the same time our senses have been dulled by the platitude that "history repeats itself."

As a consequence, we have become so inured to change, especially to growth and to increase, that it is difficult for us to conceive that such has not always been the case and that similar developments may not occur indefinitely. In fact, it is difficult for us not to regard the rates of change which we are now witnessing as the normal order of things.

In order the more properly to appraise where we now are and the limitations which may be imposed upon our future, it is well that we consider in historical perspective certain fundamental relationships which underlie all our activities. Of these the most general are the properties of matter and those of energy.

From such a point of view the earth may be regarded as a material system whose gain or loss of matter over the period of our interest is negligible. Into and out of this system, however, there occurs a continuous flux of energy in consequence of which the material constituents of the surface of the earth undergo continuous or intermittent circulation. These material constituents comprise the familiar chemical elements, only a few of which, occurring in but a few parts per million, are significantly radioactive.

For the present discussion we shall restrict our attention to the nonradioactive materials and shall summarily state that the events under consideration are the result of a flux and degradation of a supply of energy, and the corresponding circulation of matter regarded as consisting of nontransmutable and indestructible chemical elements.

All but a minute fraction of the energy involved in this process is that derived from solar radiation, and a small part of the matter at or near the surface of the earth occurs in the peculiar aggregates known as living organisms. A part of the solar radiation incident upon the earth serves to propel a circulation of matter into and out of this organic assemblage, and in the process an amount of energy roughly proportional to the mass of the matter incorporated into organisms is held in storage as chemical potential energy.

From geological evidence, organisms have existed upon the earth for probably as long as a billion years. during the last 500,000,000 of which a fraction of these organisms have become buried in the accumulations of sediments under conditions which have prevented complete disintegration and complete loss of their energy content. Consequently, there exist in the sedimentary rocks of the earth today accumulations of the remains of fossil organisms in the form of coal, oil shale, and petroleum and natural gas, which are rich in fossil energy stored up from the sunshine of the past 500,000,000 years.

This process of accumulation is doubtless still occurring, but the rate is probably not very different from that of the past, so that, for an order of magnitude, the accumulation during the next million years will probably not exceed 1/500th of the accumulation which has occurred already.

With this background let us consider the development of the human species. From archeological and geological evidence it appears that evolution had proceeded far enough that a species recognizable as *man* must have existed roughly a million years ago. The population of this species at that stage is unknown, but evidently was not large. It existed in some sort of ecological adjustment with the rest of the organic complex and competed with the other members of the complex for a share of solar energy essential to its existence. At that hypothetical stage its sole capacity for the utilization of energy consisted in the food it was able to eat—the order of 2,000 kilogram-calories per capita per day.

Between that stage and the dawn of recorded history, in its achievements this species is distinguished from all others by its inventiveness of means for the conquest of a larger and larger fraction of the availamle energy. The invention of clothing, the use of weapons, the control of fire, the domestication of animals and plants, and many other similar developments all had this in common: *they increased the fraction of solar energy available to the use of the human species, and they continuously upset the ecologic balance in favor of an increase in numbers of the human species,* with corresponding adjustments in all the other populations of the complex of which the human species was a member.

From that early beginning until the present day this progression has continued at an accelerated rate. It involved the development of wind power and water power, the smelting of metals with wood as fuel, the extensive employment of beasts of burden. However, throughout this period until the last few centuries the *rate* of these changes was sufficiently small that population growth was able to keep pace. The energy consumed per capita, therefore, increased but slightly. (Complete paper to be published in *Science.*)

THE UPPER ATMOSPHERE

The Sun and the Earth

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Recognition of the fact that the sun has a direct influence upon the earth antedates human history. The division of time into day and night and the partition of the year into seasons depend upon the relative aspects of earth and sun. The squirrel who stores nuts for the winter instinctively appreciates the effect that the changing position of the sun has upon the weather. Our primitive ancestors resorted to sun worship and to sacrifices in an attempt to control or influence a power of such obvious importance.

We cannot now reconstruct the primitive arguments evoked by our ancestors in favor of sun worship. In all probability the obvious fact that one summer may differ exceedingly from the previous or following summer may have had something to do with the development of solar religions. For, if the character of seasons recurred as regularly as the sequences of day and night, the ancients would have had no basis for assuming that they could influence the weather by religious rites.

Even today, we are still unable to answer the question why one summer may bring rain and a bountiful crop and the next only a killing drought. The position of the sun has repeated with geometrical exactness. Are the intrinsic variations of the sun, of which the well-known sunspot cycle is an example, responsible for the differences? Or is the earth's atmospheric circulation so extremely complex that the solar influence, however variable, is only a minor complication?

Until recently, most meteorologists have been inclined to accept the second proposal as true. However, here and there various meteorological phenomena have shown periodicities suggestive of the 11-year sunspot cycle. And Haurwitz has shown that temperature changes within the ozone layer may produce large-scale motions of air masses at lower levels. The theory is far from complete, but it does suggest that the clue to long-range weather forecasting may lie in the upper atmosphere and, more particularly, in phenomena controlled by changes in solar radiation.

Certainly, it is in the upper atmosphere that we find the most evident effects of solar variability. In the ionosphere—the layers of electricity that reflect radio waves to great distances around the earth—we find two marked effects of changes of quantity of solar radiation with the sunspot cycle. The number of electrons in the various ionospheric layers is greatest when spots are most numerous. The study indicates that the ultraviolet radiation responsible for the electrification of layers increases by a factor of about 16 from sunspot minimum to maximum.

In addition to the rise and fall of ionization with the sunspot cycle, the ionosphere is subject to disturbances that are also associated with solar activity. There are the so-called "sudden ionospheric disturbances," which occur simultaneously with a burst of ionizing radiation from the sun. Some region of the solar atmosphere, most commonly in the neighborhood of a large, active sunspot, becomes extremely bright and hot. We observe a brilliant flare in light of hydrogen. The radiations from the flare apparently penetrate to the lowest ionospheric levels, where they increase the electrification. Short-wave radio signals are strongly absorbed in this region of atmosphere and may completely "fade out" for a period of minutes or hours, until the solar flare dies away.

The second type of disturbance has its greatest effect in the upper levels of the ionosphere. The electrified region pulsates, and the amount of electrification usually decreases. Brilliant aurorae and intense magnetic storms (fluctuations of the compass needle) often accompany the ionospheric disturbances.

We still do not have any really satisfactory theory of ionospheric storms of this type. Most of us believe that the earth has encountered a large cloud of electrons and ions, ejected by the sun. Although we photograph the sun daily and often see explosions, there is little definite evidence that the moving material actually leaves the sun. The streamers of the solar corona are, perhaps, the best evidence for the existence of ejected matter.

We are now in a scientific period where intensive study of the sun, together with simultaneous study of many types of terrestrial phenomena, should lead to discoveries of vital interest and practical value. And, in our search for clues related to weather causes, we should remember that our present climate—variable as it is—has not been representative throughout geological history. The earth has undergone a number of separate and distinct periods of glaciation, with interim periods when the climate was appreciably warmer than at present. Magnolia trees once flourished in Greenland, for example.

Within the past million years the earth has experienced four separate periods of glaciation. None of the various possible causes proposed to account for the onset of the ice ages appears to be adequate. There is good reason to believe that the glaciation occurred simultaneously on all continents and probably in both hemispheres.

Geologists and meteorologists have hesitated to ascribe the variability of terrestrial climate to a solar cause. But many have gradually come to the conclusion that a solar origin is the only remaining acceptable hypothesis. A million years is only a small amount of time in terms of the age of the sun or earth. Any variations in the output of solar heat cannot be attributed to evolution. But we cannot disprove, at the present time, the suggestion that the sun may have a long-range variability in addition to its 11-year cycle.

However, there is one other possibility to consider—a possibility that has not been previously suggested, to my knowledge. There are, in space, many extended objects known as dark nebulae, clouds of dust that obscure the light of the stars behind or inside them. In the course of geological time our sun has probably passed through many such nebulae.

A dark nebula is so tenuous that the materials between the earth and sun would exert a negligible effect on the amount of heat and light reaching us. But an extensive cloud—even if partially transparent—could scatter an appreciable amount of radiation back to the earth. At the first sign, one might conclude that the excess radiation would produce an effect just the opposite to that of an ice age. However, a cold age is not necessarily an ice age. Accumulation of ice and snow requires both high evaporation of water from the oceans and high transport of the moisture-laden air to the poles.

If the sun has been traversing a dark nebula, from which it emerged only some 50,000 years ago, the denser portions of the nebula might give the warm interglacial periods and the less dense regions the eras of ice accumulation. If this theory is correct, the outer fringes of the nebula are only about one parsec away (a parsec is about 20 million million miles, or 4 light years), in the direction of the constellation Columba. Since the nebula as a whole may be very thin, compared with the average dark nebulae, its effect on the light of more distant stars will be negligible. This hypothesis is far from proved, but it suggests a new approach to the old problem of the glacial periods.

Cosmic Rays in the Stratosphere

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It is known to physicists that a radiation consisting of charged particles enters the earth's atmosphere from the outside. This so-called "cosmic radiation" has a flux of about 0.12 particles/cm^2/sec/unit solid angle at a geomagnetic latitude of 50° N. Of what possible interest can a radiation of such extremely weak intensity be to scientists? We must be very clear about this point, since physicists are now concentrating a great effort on exploring the exact nature of cosmic-ray phenomena. That we are dealing here with a radiation of very extraordinary nature is given by the fact that each individual particle in the cosmic radiation carries an energy much greater than anything which has been explored in nature. The average energy of a primary cosmic-ray particle is estimated to be close to 10 billion electron volts. It was found, however, that some of the individual cosmic-ray events correspond to energies as high as 10^{16} electron volts (10 million billion electron volts). It is then obvious that in the field of cosmic radiation there arises the fundamental problem of whether or not the basic laws of physics which were proved to be valid for lower energies still hold for these extremely high energies. This applies, in particular, to the problem of the nature and properties of our fundamental particles, which could not be studied in sufficient detail in the domain of low energies. It is also expected that a thorough study of high-energy nuclear phenomena will lead to a deeper understanding of the short-range forces holding the atomic nucleus together. As a matter of fact, at the present time we find ourselves in a very confused situation with respect to these fundamental problems. This might be somewhat surprising in view of the fact that great progress has been achieved in the general understanding of microscopic phenomena with the aid of electromagnetic and quantum theories. However, the knowledge gained from low-energy processes seems definitely insufficient. Two facts demonstrate this is a striking way:

(1) The occurrence of new fundamental particles like the μ-mesotron, the π-mesotron, and the neutral mesotron. (A mesotron of mass around 700 electron masses is also eventually present in the cosmic radiation.)

(2) The discovery of new fundamental interactions between elementary particles like the creation of a mesotron, its nuclear capture, etc.

At present there are two possible ways to penetrate into the field of very high energies: (a) by using the natural source of high-energy particles in the cosmic radiation, and (b) by using artificial sources (accelerators). Method (b) has the great advantage over (a) that, by using accelerators, one can investigate high-energy phenomena under controlled conditions. On the other hand, (a) is superior to (b) in the direction that, in the cosmic radiation, individual particles of such high energy can be found that even the most ambitious construction program of accelerators cannot compete with nature on this score. Therefore, gaining further knowledge of cosmic-ray phenomena seems vital to physics.

Cosmic-ray studies in the high atmosphere are of particular interest since the collisions of primary particles with atomic nuclei of air are relatively frequent events at these altitudes. This process gives us the possibility of investigating nuclear interactions at particle energies of several billion electron volts. The experimental results indicate that we are dealing here with one of the most interesting new processes in nature. Under the action of a primary the nucleus explodes into a number of fragments, and, in addition, new particles like mesotrons are created simultaneously. The nuclear fragments (protons, neutrons, plus other nuclear particles) and the mesotrons are projected into the atmosphere with considerable speed. According to recent experiments of Bridge, Rossi, Fretter, and others, electronic radiation is also released in some cases in collisions of primaries with nuclei. The secondary particles represent, then, the bulk of the cosmic radiation at lower atitudes. On the average their energy is lower than that of the primaries. The important region of the atmosphere in which the conversion of most of the primaries into secondaries occurs lies between the top of the atmosphere and an altitude of 11 miles (roughly 1/10 of our atmosphere by weight). This is then, the region in which we can study best effects pertaining to primary cosmic rays.

Some of the interesting problems under attack are: (1) nature and origin of the primary cosmic radiation, (2) collisions between primaries and atomic nuclei, (3) properties of the various particles found in the cosmic radiation, (4) intensity of the various cosmic-ray components, (5) influence of the earth's magnetic field on the motion of cosmic-ray particles, (6) fluctuations in the cosmic-ray intensity, and (7) correlation between atmospheric changes and variations in the intensities of the various components.

At the present time many of the above-mentioned problems are still unsolved. We shall therefore limit ourselves here to giving a very brief description of some of the techniques used in cosmic-ray research in the stratosphere and then describe a few of the results that have been obtained.

Most of the cosmic-ray investigations in the stratosphere were carried out with the aid of Geiger-Müller counters and ionization chambers. Anderson and his collaborators used cloud chambers in a B-29 plane. Cloud-chamber pictures were also obtained in balloons by Anderson's group and by the cosmic-ray group at Minnesota. The technique of tracks in photographic emulsions was frequently used during the past year.

The above-described instruments were carried into the stratosphere by V-2 rockets, balloons, or airplanes. Rockets reach altitudes of about 100 miles, balloons about 100,000′, and B-29 planes about 40,000′.

A number of slides illustrate important features of experimental techniques used in the stratosphere.

The following points are discussed: (1) What is the nature of the primary cosmic radiation? (2) What are the main cosmic-ray components in the stratosphere? (3) What are the essential interactions between cosmic-ray particles in the high atmosphere?

The various cosmic-ray components and nuclear explosions and mesotron tracks recently obtained in the stratosphere are shown by diagrams and pictures.

The Circulation of the Upper Troposphere and Lower Stratosphere

C. G. Rossby and H. C. Willett
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The great increase of observational data from the upper troposphere and lower stratosphere, obtained in recent years by radiometeorograph and radar, has extended and somewhat modified the accepted picture of the circulation of the earth's atmosphere in the higher elevations. In particular the jet-stream characteristics of the circumpolar vortex, *i.e.* the west-wind belt of middle latitudes in the upper troposphere, are difficult to reconcile with earlier conceptions of the operation of the general circulation. This jet maximum of the westerlies near the tropopause in middle latitudes normally exceeds a velocity of 100 miles/hr in winter and occasionally reaches nearly twice that speed.

By emphasizing the principle of the conservation of absolute vorticity, rather than the conservation of angular momentum, in the lateral mixing processes in a gaseous envelope such as the atmosphere, Rossby has been able to offer a plausible explanation of the jet-stream characteristics of the circumpolar vortex in the vicinity of the tropopause. This same principle appears to explain also the zonal distribution of rotational velocity in the solar atmosphere, and phenomena such as the observed equatorial ''accelerations'' on the planets Jupiter and Saturn. On the basis of the latitudinal transport, by lateral mixing, of absolute vorticity and heat, combined with the gradual re-establishment by radiational processes of the latitudinal thermal contrast, Rossby can offer a hypothetical explanation of the large-scale irregular fluctuations of the general circulation.

The principal difficulty with Rossby's explanation of the operation of the general circulation lies in the fact that it requires, in the mean, an effective equatorward transport of angular momentum in the upper troposphere at all latitudes. It is difficult to reconcile this requirement with the observed distribution of east winds at sea level between the polar and the subtropical latitudes, and with the observed latitudinal transport of angular momentum in the middle troposphere. There exists also the possibility that irregular direct solar influences are partly responsible for the erratic character of the major irregular fluctuations of the general circulation. (Complete paper to be published in *Science*.)

WORLD HEALTH PROBLEMS

The Global Concept of Disease

Ernest Carroll Faust
Tulane University

Disease results from the destructive action of pathogenic microorganisms, malnutrition, the dysfunction of organs, abnormal tissue growth, poisons, and the process of aging. Because of climate and its effect on the human body, many diseases are more prevalent in humid tropical countries, but malnutrition and the common communicable diseases are world-wide in their distribution. Dissemination of disease has been greatly increased by wars, pilgrimages, migration of peoples, and the need for more productive land for congested populations.

During the past century the causes of disease and the methods whereby diseases are contracted have been elucidated, and with this knowledge many disease entities have been brought under control in certain countries. Yet disease is global in its extent, and control measures must be conceived and carried out on a global scale. This must be under the direction of a single coordinating agency, the World Health Organization.

Influence of Modern Developments in Nuclear Energy Upon Public Health Problems

Stafford L. Warren
University of California at Los Angeles

The atomic bomb project and the attendant research in various fields of nuclear energy have had a tremendous impact on public health problems in both the general and the strict usage of the term "public health." This research has resulted in opportunities to learn about aspects of biology and medicine hitherto beyond the reach of research methods. It has introduced the possibility of contamination of air, water, and food on an industrial and public scale never before imagined. Thus, a new profession, that of the health physicist, or radiological safety monitor, has been created. It presents a new threat to mental public health in the fear of war, for we as a nation are perhaps more vulnerable than any other nation to the destruction and contamination an atomic war would bring upon us.

Certain direct benefits to the public health field from the nuclear energy war program can be easily recognized. Some of these are unique, and some are matched by research contributions from other war projects.

(1) The medical-biology program of the Manhattan Project had a definite goal and a deadline to meet, and it received unlimited support. It has demonstrated that large-scale medical and biological research can be carried out by teams and that good progress can be made in studying basic problems while conducting at the same time what may be called applied research or programmatic research. In fact, each type of research in the Manhattan Project complemented and enhanced the other. The achievements in basic science of these teams of researchers, working under pressure toward a specific goal, suggest that sterility of ideas in research is definitely a symptom of starvation and frustration of opportunity rather than of lack of capacity. I believe this to be one of the most important contributions of the war in medicine, because the application of these same broad principles of continued optimum subsidy of group research could speed progress in medicine and biology now as never before. The principle of group programming and self-disciplining was well developed and is responsible in great part for the present trend to utilize the mechanism of institutional grants for research over a broad field in the place of grants to individual investigators in specific fields, such as cancer research, heart disease, etc.

(2) The health-safety program (industrial hygiene) of the Manhattan Project and the Atomic Energy Commission has defined and emphasized the importance and the role of similar organizations in industrial plants and has shown the need of better standards and of well-trained men. This health-safety program contributed heavily to the war effort by reducing absenteeism, morbidity, and the cost of compensation claims. The unparalleled record of protection from all types of injury in the Manhattan Project, and now continued under the AEC, emphasizes the value of intelligent cooperation between management, plant and laboratory personnel, and the health-safety group. New research data were and are utilized promptly to set the standards for safe working conditions and to furnish methods for detecting the earliest evidence of injury and for possible methods of treatment in case of accident or violations of the regulations. The practical value of a strong and vigorous industrial hygiene program in industry is thus well demonstrated and should gain acceptance in industry the country over.

(3) The public health and medical care programs in the isolated communities of the atomic project have demonstrated that good medical facilities and care pay off in dollars as well as in high morale and stability of

personnel and in low morbidity and mortality from the common diseases.

(4) Many of the isotope research techniques and equipment developed during the war were the outgrowth of small beginnings before the war. The improvements in the use of both stable and unstable radioactive isotopes, plus their ready availability from atomic energy sources, have opened up avenues in medical and biological research unreachable before the war. The equipment and accompanying facilities are expensive. These techniques are most effective when employed by a coordinated team of men from a variety of fields. The avenues thus opened to the imaginative researcher in universities, industrial research laboratories, etc. are almost limitless. By using carbon, hydrogen, oxygen, and nitrogen of various masses, the chemist is able to trace the realignment of various parts of the molecule in the process of formation of new substances from marked known substances. The biologist, the biochemist, the pathologist, physiologist, etc. can study the utilization of these marked substances in the body in every system and can study the dynamic changes in function, injury, repair, absorption, transport, excretion, etc. from every aspect of his interest. Such research cannot all be done at once. Tremendous strides in this direction, however, have taken place over the Nation and, in fact, in the rest of the world, for almost every university is either working with isotopes now or attempting to obtain the money, equipment, and men to do so. Not the least part of the product of this resurgence of research is the training of new and young men in these techniques.

Widespread use of radioactive tracers in metabolic and other studies over a period of years will require that the same safety and protective regulations that exist in the current AEC plants are carried out faithfully during peacetime. Otherwise, insidious contamination of sewers and, in terms of streams, water supplies and possibly food will eventually occur all over the country. It is mandatory that the safeguards required by the AEC be carried out meticulously in all such research in order to protect everyone. These safety techniques must become routine, and their cost should be included in the cost of the experimental program from the beginning and not as an afterthought when complications arise. The concentrating power of plants and other biological materials should not be overlooked in the case of certain long-lived radioactive isotopes that are normally used by them. Familiarity with the research and protective techniques removes the fear of the hazard, although the hazard still remains.

The greatest hazard of all lies in the use of atomic weapons in war. The knowledge that such a hazard might exist has been widely disseminated since the end of the last war; yet the complete picture of a full-scale atomic war is so devastating that few have given the problem the emphasis that it deserves. Some scientists and the population as a whole view the contingency through a haze of mingled optimism and fear. Many have developed a fear neurosis concerning it which clouds their thinking and acting. Some think that the danger is grossly overrated. This very combination of fear and the defensive reactions which fear arouses (both direct and indirect) may become a serious public health problem. Part of the difficulty lies in the time that must elapse for the proper education of the public in the technical problems which the people must face in order to protect themselves. Part lies in the unwillingness of the governments of the world to view modern war in its true light. Fire bombing, although it takes planes and men in huge numbers, is one of the most effective large-scale destructive agents so far devised, but, aside from large-scale destruction and death, as bad as they are, there is no other aftermath. With the other major destructive agent, the atomic bomb, the same destruction, fire, and death are achieved more uniformly, and, when properly applied, a fantastically widespread contamination with radioactive materials can be left behind that will defy all public health measures for complete protection for a long time, measured in years, even decades. Such a circumstance would create the greatest public health problem of all time. Since at least two nations would be involved, contamination hazards to health would extend into large areas of the globe. As educators, we all know that our people and our Nation do not wish such a thing to happen. The solution of this health problem unfortunately does not lie within our province alone. Whether the die is ever cast depends upon the willingness of all nations to agree to permanent peace. The best antidote for fear is a well-defined, intelligent course of action. Therefore, public health authorities, educators, and the new Office of Civil Defense have a direct responsibility to the public to: (1) spread accurate, readily understood facts and knowledge about the nature of atomic war, (2) plan specific programs for public protection, (3) train radioactive safety crews for public protection, and (4) give the public specific information for its own protection in case of widespread contamination and general information on catastrophe from any cause. In any situation it is the informed and trained individual who has the best chance of protecting himself.

Medicine and Public Health in the International Scene

Leonard A. Scheele
U. S. Public Health Service

EDUCABILITY

Educability and the Schools

Ralph W. Tyler
University of Chicago

Educability is conceived as potential capacity to succeed in the present school system, with its present ends and means. So conceived, it can be measured, and success in school can be predicted with fair precision.

Prediction based on this concept of educability is, however, unsatisfactory, for the reason that present educational ends and means are inadequate. Reliance upon them results in denial of educational opportunity to those who need it most.

We need a broader concept of educability as potential capacity for socially or personally valuable behavior. Educational research should identify and measure those potential capacities that may be developed by the schools and that are indices of success in all walks of life. Development of these capacities should become the end of education. Educational research should also investigate learning in all aspects of human experience so that educational means may be improved.

The Growth Potentials of the Human Infant

Arnold Gesell
Yale University

All educability is dependent upon innate capacities of growth. The child inherits these capacities from immediate and remote ancestors. Every child has a unique pattern of growth which is the basis of his individuality and of his ability to profit by experience. Growth can be guided, but it cannot be imparted by environment or education. The child's growth potentials are part of his constitution, and he is fortunate if he is born with a favorable equipment of genes, because he must do his own growing. The culture with the aid of science can give the child wise assistance if it understands and takes heed of his ways of growth.

These are the conclusions of systematic investigations made at the Clinic of Child Development, School of Medicine, Yale University. The speaker demonstrated the nature of these investigations by means of a sound film which depicted the stages of natural growth in the patterning of infant behavior. Utilizing motion-picture cameras, the Yale Clinic has documented thousands of behavior patterns at 34 progressive age levels from birth through the first 10 years of life. Cinema and stenographic records were carefully analyzed to chart the progressions of growth in the four major fields of behavior—motor, language, adaptive, and personal-social.

These studies show that the mind of the infant is a complex action system which matures in a lawful step-by-step manner in all fields of behavior—in the coordination of eyes and hands; in creeping, standing, walking; in language, imitation, and social communication; in emotional expression; in his fears, affections, and curiosities; his attitudes toward mother, father, and playmates; his judgments of right and wrong; his sense of humor; and even in his ideas about life, death, and nature. The orderliness of the growth process is evidenced in the sequences of block-building: at 4 weeks the infant looks at a 1″ block; at 24 weeks he picks it up not only with his eyes but also with his hands; at 28 weeks he bangs with blocks; at 18 months he builds a tower of three blocks; at 2 years, a wall; at 3 years, a bridge.

Such a sequence may be called a law of nature. Similar sequences prevail in all fields of psychological growth, including personality as well as intelligence.

The mechanisms of human growth are culminating end products of ages of evolution. The race evolved; the child grows. Each and every part of the child's make-up has to grow—bones, brains, and behavior. The laws of growth are as ubiquitous and pervasive as the laws of gravitation or of atomic energy.

The child's abilities and his educabilities are governed by the underlying maturity of his behavior patterns. The forms and lawful sequences of growing behavior patterns can be defined by the life sciences, including a clinical science of child development. More knowledge needs to be applied at the beginnings of the life cycle to reduce the mounting tide of adolescent instability and of adult abnormalities of behavior. Through broadened methods of developmental diagnosis and supervision in infancy, through individualized growth guidance in nursery and elementary schools, we can strengthen the stamina of the child and of the family unit. We can discover distinctive gifts and talents in the early years of life. We should place more stress upon the positive and constructive expressions of child development, particularly in the first 5 years of life, which are basic for all later development. The intrinsic badness of children has, in my opinion, been vastly exaggerated by distorting interpretations. Well-constituted children with healthy inheritance have an intrinsic charm—a charm which betokens intrinsic goodness. The growth potentials for good exceed those for evil, unless the cultural odds are too heavily weighted against the child. (Full paper to be published in *The Scientific Monthly.*)

The Social Environment of the Educational Process

Talcott Parsons
Harvard University

The problem. Biological plasticity provides the opportunity for all human educability. But man is a social animal in a special sense. His interdependence with others in the social system on the one hand limits the biologically possible range and on the other lays the foundations of specifically human educability—e.g. language and emotional capacities.

The case of German re-education. Widespread ideas of re-educating the German people for democracy by removing Fascist or Nazi influences from textbooks, press, and radio and substituting democratic ideas illustrate neglect of dependence of education on the social system. So far as German nationalism was a product of the special German society, susceptibility to it cannot be removed without far-reaching social changes. If these do not take place, there is a serious danger of intensifying this susceptibility rather than the reverse—the "boomerang effect."

Approach to the sociological analysis of educability. Social systems are now known to operate not only by deliberate rational action of their members but, underlying this, by an intricate system of automatic and semiautomatic adjustment processes—analogous to the biological. For this to be possible, people must be very specifically adjusted to the needs of the particular society. This is only conceivable if education or "socialization" in the broadest sense is thought of as an integral part of the functioning of the society itself as a system. This is true on all levels, but pre-eminently that of the subtler elements of personality structure adapted to the needs of a particular society.

The relevant aspects of social systems. Social systems consist of interacting behaviors of people. These, however, are crystallized in relatively stable patterns—in structural terms, institutions. In terms of behavior of individuals institutional patterns define roles—expectations which the incumbent of a given status must fulfill. Psychologically, the role system makes it possible to mobilize all principal elements of motivation (in the integrated case) in the service of behavior which will promote the functioning of the larger social system.

The system of institutionalized roles is relevant to educability in two senses. First, the process of education sociologically considered is essentially the processes of establishing the integrations of motivation appropriate to the various roles of the social system. Second, the role system itself provides a crucial component of the mechanisms by which these integrations are brought about.

The components of such an integration of motivation may be said to rest on three interdependent levels. First is what has sometimes been called basic personality structure—the fundamental attitude tendencies of the personality with respect to authority or submissiveness, to active achievement or withdrawal, to accepting or evading responsibility, to openness to affective contact with others or emotional withdrawal. Second is the symbolic definitions of situations and goal systems of the society, the orientations toward achievement and success, toward proper relations toward the opposite sex. In one aspect this is what is generally referred to as "ideals." Third is the level of specific knowledge and skills of the types ordinarily taught on "academic subjects." On a common-sense level, the last are by far the most susceptible to deliberate rational control. The others have proceeded mainly by automatic process but are subject to some control if the forces operating are scientifically understood.

Education as a process within the social system. Broadly, the last of the above levels is that of education imparted by deliberate teaching, the first by informal processes, the middle by a mixture. The "deeper" levels are laid down in the process of social interaction with emotionally significant persons. Three primary roles of great educative significance in our society should be distinguished: those of parent, of peer group member, and of teacher.

All operate by unconscious processes. The parental role combines establishment of disciplines with emotional support necessary for assimilation of discipline. Beyond a certain point there is danger of fixation unless emancipation occurs. The parents are the earliest role models. The peer group is the primary field of free experimentation with social role skills. It is of particularly crucial significance in American democracy. The teacher is more impersonal and "universalistic" than the parent. The role is crucial in mediating emotional transition to participation in the wider society. In America special problems are raised by the role of the woman teacher as a role model, especially for boys.

The role of teacher has analogies to that of physician. Precisely by being outside the more intensive emotional interactions of the family is it possible to help the child in making his emotional emancipations. This emotional emancipation underlies the pupil's capacity to be taught specific subject matter.

Education and social control. The educational system of a society is indeed deeply rooted in the whole social system. It is not, therefore, unchangeable. It is, moreover, a most strategic point from which to modify the system. But this can be done successfully only if one uses the total balance of social forces in the social system as they infringe on the educational structures. The American faith in education is not misplaced. But it needs to be implemented with a maximum of scientific sophistication. One must work in and through the social system, not against it.

SCIENCES OF SOCIETY

Sociology

Samuel A. Stouffer
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Is Economics Necessary?

Kenneth E. Boulding
Iowa State College

Being an economist, I can hardly be expected to answer "No" to the above question. I intend to examine briefly the type of contribution which economic theory makes to science in general and to the social sciences in particular.

Economics has the not-undeserved reputation of being one of the most "successful" of the social sciences, in that it has produced a considerable body of propositions that are widely accepted by competent persons. Nevertheless, there has been something of a smoldering revolt against its methods, especially by students of economic institutions. Some of this is due to misunderstanding, some to emotional biases, but there is a residue of justice in it.

The method of economics is that of a logicomathematical analysis of the necessary relationships of certain selected quantities, such as wages, prices, outputs, etc. on the assumption of certain functional relationships between them and of certain principles of selection among alternative opportunities. As a system of analysis it gives us—like any mathematical science—simply a system of hypothetical propositions: if A, then B. Whether A or B is true or false is a matter for empirical inquiry. Nevertheless, no economist is quite "pure": his "models" are inevitably biased in favor of the world as he sees it, just as elementary geometry is biased in favor of Euclidian space. In the endeavor to explain the relationships of so-called ''economic'' variables, however, the economist has been gradually forced into a much more general theory, so that now economics has become essentially the general theory of choice, *i.e.* of the implications of ''scarcity.'' As such, the conclusions of economics not only are relevant in the small sphere of so-called ''economic institutions'' (money, banking, firms, etc.) but apply wherever choice is necessary, which means that they apply almost universally—to art, music, government, and even to theology. Moreover, in developing a pure theory of choice, economics has been forced by the case of oligopoly to develop a theory of strategy where the choices of several individuals are reciprocally dependent.

Economics has also made an important contribution to scientific method in that it has been forced to develop techniques for handling complex general equilibria. These are found in many sciences—e.g. general planetary equilibria in astronomy, ecological equilibria in biology, and so on. The problem is of overwhelming importance in economics, however, and three approaches have been developed toward it: the *cereris paribus* approach of Marshall, the simultaneous equations method of Walras, and the macroeconomic methods of Keynes. Of these, the third seems to be at once the most dangerous and the most fruitful; in it the system is considered as a whole in terms of a few aggregates. The method should be applicable in many other sciences.

Finally, economics is necessary because of the great practical importance of the universe it investigates. The survival of our civilization depends perhaps on the answer to an intellectual problem: whether Marx was right about the self-contradictory nature of capitalism. Even more than the solutions it may yield, however, economics is necessary for the state of mind it produces: in a day when self-interest, statism, militarism, and a dreadful pride threaten our very existence, economics inclines toward the general interest, points out that this is not incompatible with individualism, urges that trust is the source of power, and by its very failures induces that humility without which we shall all be destroyed.

''It is not an exaggeration to say that, at the present day, one of the main dangers to civilization arises from the inability of minds trained in the natural sciences to perceive the difference between the economic and the technical'' (L. Robbins).

Have Civilizations a Life History?

Alfred L. Kroeber
University of California

How far may we justifiably separate or distinguish civilizations; and how far are these separate civilizations, nevertheless, repetitive, recurrent, and similar in type and in their life histories?

Most major civilizations are supernational. A major civilization is normally multinational and multilingual, though it may possess one standard language. Each civilization has a fundamental ideology, a coordination of cultural patterns, a master pattern. The process of cultural growth from shadowy, groping beginnings, through selective commitment, to particular forms or patterns, and growing control of these until they are achieved and their potentialities are realized—this process seems to be basic in the history of civilizations.

A corollary of the foregoing findings concerns genius. Great men notoriously cluster in time and place. The pattern and master-pattern interpretation of civilization explains this clustering. Great men can appear only while great patterns are in the shaping during the life history of a civilization. At other times native genius is wasted—it has nothing to take hold of, it leaves no achievement that permanently means something. It must be civilization that is the cause of the fact that the overwhelming majority of the men whom we unanimously recognize as great have lived in the great periods of great civilizations. (Not abstracted by author.)

PROBLEMS OF THE OCEAN

Biological Problems of the Ocean

Daniel Merriman
Bingham Oceanographic Laboratory

An Analysis of the Stirring and Mixing Processes

Carl Eckart
Scripps Institution of Oceanography

The terms ''theoretical'' and ''empirical'' are both often used in a derogatory sense. Especially in the first enthusiastic rush of discoveries in a new field, theory is apt to be frowned upon as bearing no relation to fact. This has some justice, because usually the true theory of the processes has not yet been developed.

One pair of related processes whose theory has scarcely been studied are those of stirring and mixing. In the laboratory, the mixing of two liquids in a beaker with the aid of a stirring rod is such a commonplace operation that its theoretical analysis seems unnecessary. In the ocean, the intermingling of water masses is one of the most basic phenomena and deserving of the most careful theoretical analysis.

The transfer of heat from one part of a solid to another occurs solely by molecular conduction. In the case of a liquid mass, transfer of heat can also be brought about by the actual motion of one part of the mass relative to another. This is clearly exemplified by stirring a stratified mass of water. Empirically, stirring is found to hasten the disappearance of temperature differences.

Theoretical analysis confirms this observation and gives a detailed account of the mechanism by which this is accomplished. The relative motion caused by stirring brings warm and cold masses of liquid into closer juxtaposition, but does not alter the temperature difference existing between a given pair of masses. It does, however, increase the temperature gradient or space-rate of change of temperature. Since the molecular conduction of heat is proportional to the temperature gradient, stirring increases the molecular conduction.

The effect of conduction is to decrease any existing temperature differences. In the case of liquids, this molecular process is properly called mixing. Stirring, so to speak, sets the stage for mixing. After a preparatory phase, whose duration is calculable in simple cases, the mixing process becomes so rapid that it is dominant.

Calculation indicates that, in stirring warm water into a beaker of cold water, the time required for the mixing process to begin is of the order of seconds. In the ocean, it may be of the order of days or even years. But the ocean has been in existence for much longer than this, and the wind has been stirring it throughout that time. Consequently, contrary to opinions sometimes loosely phrased, the molecular processes predicted by theory must be occurring in the ocean and influencing its behavior. In fact, if the ocean is really in a state of dynamic equilibrium, these molecular processes must determine that state. (The full article on which this abstract is based will be published by the *Journal of Marine Research* under the title "An Analysis of the Stirring and Mixing Processes in Incompressible Fluids.")

Oceanography and the Oceans

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One hundred years ago the waters beneath the ocean surface were virtually unknown. Scientists had been preoccupied with unraveling the many mysteries of the land. Furthermore, the study of the depths of the great ocean basins and life and the conditions in them had to wait until means were devised to lower and raise heavy instruments. The sailing ships of a hundred years ago had only the strong arms and backs of the crew to operate hoisting gear, and it was not until steam power was available on ships to operate their winches that the science of oceanography could flourish.

A century ago our ideas about the oceans were based on scanty and often incorrect information that led to many misconceptions. It was believed that the deep waters were barren of life and that the depths were fantastically great. The great era of oceanographic exploration was the last half of the 19th Century. Refined and rapid methods of investigation, developed in the last generation, have given us a general understanding of the seas, but there are many regions yet unexplored and many problems that have barely been recognized and for which we still lack adequate theories.

The future of oceanography lies in carefully coordinated programs involving work at sea, laboratory studies, and theoretical investigations. The observational program must guide the theorist in his work, and the latter must assist by indicating the kinds of observations and equipment that will lead to the most valuable results. The oceans form the largest single feature on the surface of the earth. The scientists of the future must give to the study of the seas the attention they merit.

FOOD AND NUTRITION

Seven Decades of Nutrition Research

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The important advances in nutrition during each of the 7 decades between 1880 and 1948 are reviewed. The period from 1900 to 1910 is characterized by a growing interest in biochemistry. The period between 1920 and 1930 is described as a transition stage between the early unstandardized animal studies and the more effective approach resulting from a greater chemical interest. The decade from 1930 to 1940 will undoubtedly be recognized as a period in history when greatest progress was made in the chemistry of essential nutrients. All the work emphasizes the importance of recognizing the nutrients taken in by the living cell, whether they be present in animals, plants, or microorganisms.

Enthusiasm over newly-discovered nutrients may have given too great emphasis to certain phases of nutrition for short periods of time, but active workers soon reinstituted the proper balance. Workers in nutrition have made use of the scientific advances in many of the related fields and at the same time have contributed to the advances in allied fields; but, in doing so, they have not diverged too far from the main goal of optimum health for all.

Cultural Contexts of Nutritional Patterns

Margaret Mead
American Museum of Natural History

In all known human societies dietary patterns are learned. Man must depend not on any instinctive equipment which guides him surely to the right foods, but upon learning as a child a form of behavior toward food that will assure him adequate nutrition. By the way in which we reward a child with one food, reward a child for eating another food, pull him away in disgust from an attempt to eat some food which is said to be only food for dogs or cattle or members of another social group, we build up a set of attitudes which enables the individual to thread his way among available foods. In primitive societies and among peoples whose diet is very meager and in which some nutrients have only minimal representation, rigid food habits have been necessary, because if the people did not adhere to a rigid pattern of including all the proper foods, they could not survive. In today's world, with modern transportation and processing, foods are available in such great variety that mankind now faces the need to learn how to be flexible and yet choose a good diet.

Future dietary patterns, in which we make full use of nutritional research, of natural resources, and of our knowledge of individual psychology and of the cultural behavior of human groups, may result in tapping possible human capacities to make individual food choices that will be superior to the fixed traditional dietary patterns of the past. However, the most pressing problem in nutritional change today is to guard individuals and groups in periods of transition from the health hazards which accompany changes from an old traditional diet to new and partially understood or incompletely adopted dietary habits.

Nutrition and the Climatic Pattern of Soil Development

Wm. A. Albrecht
University of Missouri

Our westward march to the mid-continent with its extensive areas of deep and fertile soils built American prosperity and our many freedoms. Those soil resources gave individual security and thereby independence. They gave birth to the political philosophies concerning the rights of the individual in the national group. They are now being tested for their guarantee of the rights of that group in the future family of nations when problems of food and nutrition under exhaustion of soils and multiplying populations are pressing westward on a global scale.

The nomad found his good nutrition when his cow went ahead of his plow. His herds were biochemists assaying and selecting the soil as guarantee of their growth and reproduction via proper nourishment. They were not measuring its production as tons and bushels per acre under economic pressures. Their nomad owner plowed it with assurance of its delivery of the requisites for his good nutrition. But modern technological means put the plow ahead of the cow. They pushed agriculture away from more fertile soils under animal selection and into the fringes of fertility. There single crop specialization flourishes under hidden hazards for, and deficiencies in, nutrition.

The climatic pattern of soil development of the United States emphasizes the fertility of the mid-continent for protein production and nutrition of high order. This was once buffalo territory, and later the hard wheat and beef cattle area. Less rainfall and insufficient soil development to the West limit production in balanced nutrition. More rainfall and excessive development of the soil to the East represent greater nutritional problems in its delivery of mainly carbohydrates under the criterion of, and economic emphasis on, bulk. Basic to this varied food synthesis by the plants is the pattern of the chemical fertility of the soil.

Our national pattern of this delineates the ecology of the soil microbes, of the native and crop plants, of the wildlife, of the domestic animals, and of man himself. We have been late in seeing ourselves and other life according to the variation in nutrition determined by the fertility pattern of the soil. Geographic arrangements of draftee rejections, of tooth troubles, and of diseases more generally have not yet been viewed as the possible result of nutritional deficiencies going back to the soil. Whether we can see a world pattern of control by the soil seems to await the day when not only deficiencies in nutrition but hunger in terms of failing bulk compel us to recognize that the soil is in control.

WAVES AND RHYTHMS

Rhythmic Behavior of the Nervous System

Hudson Hoagland
Worcester Foundation for Experimental Biology

This paper first briefly reviews certain established facts about the nature of nerve messages and of electrical brain waves and considers these waves and rhythms in contrast to other forms of rhythmic events. The paper then goes on to discuss recent developments of electronic calculating machines which shed suggestive light on considerations of higher brain mechanisms. Work in particular of Wiener, Rosenblueth, Adrian, McCulloch, Pitts, and Northrop is reviewed in interpreting the possible role of brain waves in perception and in memory and the philosophical implications of these approaches.

The paper reports no new experimental findings. It is rather an attempt at synthesis of several fields of interest.

Ground Waves and Air Waves

James B. Macelwane, S.J.
St. Louis University

Sound Waves and Rhythms

Vern O. Knudsen
University of California at Los Angeles

A summary of the rhythmic patterns of sound waves in music, speech, and noise is given. The historical background of these ever-present acoustical phenomena is considered, starting with the Chinese, Egyptians, and Hindus and continuing with the controversial views of Pythagoras and Aristoxenus. The modern science of sound started with Galileo, who first deduced the laws of vibrating strings. The first application of geometrical acoustics to theaters was made by Kircher in 1650.

The epochal advances in the 19th Century call to mind the great contributors Biot, Fourier, Savart, Ohm, Henry, Tyndall, Stokes, Kirchhoff, Lissajous, and Helmholtz, and the monumental work of Rayleigh.

Mention is made of the great low-frequency disturbances produced in the atmosphere by the eruption of Krakatoa in 1883 and the Siberian meteor of 1908. This is followed with a more detailed account of waves of small amplitude. The dependence of the attenuation of such sound waves on temperature, humidity, viscosity, and heat conductivity, and contamination of the atmosphere are noted. A brief review is given of the effect of molecular collisions and fog on the transmission of audiofrequencies.

The paper concludes with a review of the rhythms of sound waves in enclosures. The theories of geometrical and wave approaches to the description of sound in interiors is reviewed in some detail, and the author's compromise solution for determining the acoustical properties of enclosures is presented. (The complete paper on which this abstract is based will be published in *The Scientific Monthly*, 1948, 67, 430.)

One World of Stars

Harlow Shapley
Harvard College Observatory

Governments and astronomical observatories have long been associated. The ancient Egyptians, Babylonians, and Chinese had their star men who mixed fact and fancy. Star-watching was the business of the old navigators and almanac makers and also, then as now, the field wherein the charlatan astrologers operated. As the needs of navigators and the deep curiosity of the human mind developed in modern times, the great nations began to build observatories. Charles II founded the Greenwich Observatory; Nicholas I, the great Pulkowa Observatory near St. Petersburg; Kaiser Friedrich, the Potsdam Observatory. In America, President John Quincy Adams encouraged the founding of the Harvard Observatory and at an advanced age traveled to Cincinnati to inaugurate the first peoples' institution for the observation of planets and stars.

In recent years astronomical collaboration on the international basis has attracted governmental attention, and the "new orders" in Mexico, Russia, and India include serious attention to astronomy, the most naturally supranational of all human disciplines.

To demonstrate the one-worldness of the stars, the many-nation contributions in the following fields are discussed: (1) measuring the distance to the sun and planets, (2) developing and using the coronagraph, (3) solving the mystery of the coronal radiation, (4) analyzing the wandering of the earth's North Pole, (5) relativity and the structure of the Universe, (6) the rotation of the Milky Way and of other galaxies, (7) the observation of total solar eclipses. (The full article on which this abstract is based appeared in *Science*, 1948, 108, 315.)

Recording the Bird Life of America With Microphone and Color Camera

A. A. Allen
Cornell University

The Laboratory of Ornithology at Cornell University is assembling a library of natural sounds, especially the songs and calls of birds, mammals, amphibians, and insects. It is believed that these recordings represent scientific facts as much as those that are ordinarily recorded by the eye. With modern methods they can be preserved for study and analyzed with as great accuracy as any other facts of nature. Moreover, the recordings can be of considerable value for educational purposes in training the ears of children to be more discriminating out-of-doors and, incidentally, help adults in identifying the multiplicity of sounds that emanate from the woods and fields and swamps, and indicate what are the animal inhabitants of any area. A special effort has been made to record the voices of birds that are on the verge of extinction, such as the ivory-billed woodpecker, whooping crane, and trumpeter swan.

The Cornell ornithologists are likewise making an effort to record the bird life of America on color film. The National Geographic Society has been assisting this project by financing a series of expeditions to the more interesting ornithological areas in North America and publishing the results in a series of articles by Prof. Allen, illustrated with color plates of the birds. Some of the more recent ones of birds in flight have been made with high-speed (1/5,000 sec) flash apparatus.

In his National Geographic Society lecture in the Ballroom of the Statler Hotel Tuesday evening, Prof. Allen showed representative selections from the color films made in Labrador, Hudson Bay, and Alaska, as well as in many parts of the United States.

On his last expedition to Alaska in June 1948, Prof. Allen's party was successful in finding and filming the nesting habits of the bristle-thighed curlew, the only North American bird whose nest and eggs were unknown to science.

In the name of the Albert R. Brand Bird Song Foundation, the Laboratory of Ornithology at Cornell has published for distribution an album of 72 songs of the common North American birds and one of 27 of the frogs and toads of eastern North America. Another album of bird songs is in preparation. Selections from these recordings accompanied the film.

Technics and the Future of Western Civilization

Lewis Mumford
Amenia, New York

Even many leaders in science and technics no longer believe that the advance of technics automatically ensures the progress of the human race. Doubts have arisen in the most advanced fields, such as nuclear physics. We now realize, as our predecessors a century ago did not, that technics may be lethally misapplied. The chief potential application of atomic energy is at present to mass extermination.

Assuming that Western civilization will survive its present crisis, what internal changes in technics must be made to bring it more directly into the service of life? The three main internal problems of technics are: the problems of time, space, and power; the problem of quantification; and finally, the problem of automatism. The conquest of space and time during the last century has fulfilled the utmost dreams of the early advocates of science and invention; but our achievements here have been steadily frustrated because we have acted as if mechanical invention would automatically solve the problems of human use and application. Unfortunately, at the moment we have achieved the technical means of a universal society, a large part of the world has relapsed into tribalism and isolationism. But modern technics itself is the product of a world-wide culture, in which even the contributions of primitive peoples like the Amazon Indians have played an important part. Unless we maintain this world-wide basis, technics itself will go backward.

The problem of quantity is the result of our expansion of power. Rejecting the notion of organic norms and human limits, we have brought about a meaningless quantification of life. In the intellectual realm, to seize an obvious example, overproductivity in publication has led to an increasing inability to assimilate the output of new material. To offset ''the poverty of overproduction'' we must change the attitudes and purposes of the human agents who operate the machine, reducing production to amounts which the human organism can assimilate and convert into an orderly, purposive, rational life.

The final achievement of machine production is automatism; but as the human agent increasingly loses control over the process, he feels insignificant and helpless, often rebellious. This is not an argument against automatism itself. We must, however, beware of the tendency of automatism, throughout our society, to bring about either paralysis of the higher functions or that condition of lethargic indifference—the vice called acedia by the monks of the Middle Ages—which is a product of perfected automatic routine. In the older realms of technics, for one Robert Young who tries to awaken his somnolent colleagues there are 10 anti-Youngs whose motto is ''anything for a quiet life.''

In short, the whole process of mechanization may be defeated unless we finally engage every part of the human personality. Otherwise, we may bring about a revolt against the machine like that Samuel Butler jokingly predicted in *Erewhon.* To overcome the present crisis, both in technics and in Western civilization, there must be a changeover from mechanical to living criteria. We must concentrate on the repressed and dwarfed elements in the personality and the community. The final question is: ''What kind of human being are we trying to produce?'' Not the Power, the Profit Man, or the Mechanical Man, but the Whole Man must be the central actor in the new civilization. The 19th-century motto, ''Mechanization Takes Command,'' must be supplemented by the principle of the New Age: Man Takes Command. (The full article on which this abstract is based appeared in *The Saturday Review of Literature* for October 2, 1948, under the title ''Let Man Take Command.'')

Science and the Control of Human Populations

Warren S. Thompson

Scripps Foundation for Research in Population Problems

Since the middle of the 18th Century the population of Occidental lands has undergone a growth in numbers and a change in distribution which in rate and magnitude are unprecedented. These revolutionary changes in population growth and distribution are, for the most part, by-products of the accumulation of scientific knowledge and the application of scientific principles to manipulating and controlling the external environment. Because they have been by-products they have received little attention, and almost no effort has been made to control or guide them in the interest of the group.

This *laissez-faire* population policy is a major departure from the policy of prescientific and nonscientific peoples. Throughout man's history measures of population control have been an integral part of the social and economic regulations by which men lived. In view of the social and economic consequences of science on man's growth, one feels justified in asking: ''Has the use of scientific knowledge released man from the necessity of systematically controlling his numbers and their distribution?'' Evidence now at hand indicates that although the control of natural processes which science has accomplished has raised the level of comfort for a small fraction of the world's population, it has solved none of the major population problems with which any people is confronted. The problems of population which demand attention today are different from those of our ancestors but are no less urgent than those which troubled them before the era of science.

The peoples of Asia are faced with a Malthusian dilemma. There, any gains in level of living which, judging from our own experience, might have been anticipated from the adoption of machine production, improvement of public health, and advancement of medicine, will probably be consumed very largely in immediate and overwhelming population increase. (In the West, on the other hand, the uncontrolled use of contraception threatens to cost the nations which have been the greatest practitioners of science their political and economic dominance.)

If one searches for reasons why societies which have made almost a fetish of science have made no effort to use science to develop measures for the control of population as an integral part of their culture, one arrives at the conclusion that at best we are only quasiscientific or semiscientific in our social outlook. The attitude persists that man and his behavior constitute a peculiar class of phenomena which are not subject to scientific investigation. Surely science forces us to conclude that a long-term adaptation to the natural environment which will insure man against eventual extinction can be attained only when this bit of folklore disappears and is replaced with an attitude which encourages the use of scientific methods to secure knowledge with which to effect better and better adaptations of man to his environment and of men to one another.

Wood in an Industrial World

J. A. Hall

U. S. Forest Service, Portland, Oregon

The beginnings of the industrial system in western Europe and the United States were built upon wood. It was with wooden tools and transportation facilities, and iron made with charcoal, that the early implements of the industrial plant were fashioned.

As men learned to use coal for power and the fabrication of steel, wood faded into the background, only to be replaced by new uses created by the needs of growing industry. Coal is mined by the use of wood for pit props, and coal, iron, and steel must move on steel rails borne on wood. The housing of new industrial centers was of wood, as were the structures of industry until industry itself had become sufficiently stabilized to require permanent structures. Even then, huge quantities of wood were used in the construction phases of steel and concrete buildings.

New industrial populations created demands for food that in turn made necessary the clearing and settling of new agricultural lands. These processes furnished in part the lumber needed to facilitate the new agriculture itself as well as to house the expanding cities. The transportation systems and communication systems that arose of necessity to bind together the complex members of the new system were borne on poles, ties, and piling, all adding to the terrific drain of the new system on the forests of the world.

The industrial system, fed by expanded agriculture, produced the improved implements with which agricultural production expanded to meet the need. Similarly, the greatly increased requirements for wood in the transformed world were met by the fabrication of new machinery for the harvesting, transportation, and fabrication of wood. Thus, the industrial system has produced the equipment with which to process the raw materials of its own being. The modifications to which wood has been subjected by the products of the industrial system itself are many and complex.

In their essence they are characterized by three principal groups:

(1) *Modifications in the physical form of wood.* New machine tools and new methods make possible useful shapes and forms of wood never possible in a handicraft age. The resin glues of chemical industry facilitate the use of veneer and small pieces of wood in the fabrication of precisely engineered structures to meet modern requirements.

(2) *Modification of the physical properties of wood while preserving its fundamental structure.* Wood is preserved against decay and protected against fire by impregnating it with various chemicals. By impregnation with modern synthetic resins and compression in heavy, hydraulic presses of modern design, new types of materials, hard, dense, and strong, are created.

(3) *Use of wood as raw material for chemical industry.* The industrial system made possible the fabrication of large, high-pressure, metal retorts and continuous, high-speed paper machines, and created heavy chemicals in large supply. These elements, reacting on wood, created the pulp and paper industry and the thousands of articles and materials based on wood pulp. New discoveries in the fundamental chemistry of cellulose promise great progress in the fields of synthetic fibers and plastics. Paper and pulp, again in combination with new resin products of chemical industry, compose a bewildering array of new and useful goods.

The expanding population of the world presses hard upon food supply and the limit of food production by traditional agricultural methods has about been reached. Wood, transformed to sugar, can aid greatly in solving the problems thus raised. Wood-sugar solutions can serve in the preparation of fermentation chemicals, the preparation of edible sugars, or as the base for industrial production of protein food.

Thus, the industrial world can feed itself, using the instruments of its own creation and its oldest and newest raw material. (The full article on which this abstract is based appeared in *The Scientific Monthly*, 1948, 67, 398.)

A Theory of the Nerve Impulse

Arturo Rosenblueth
Mexico City

Oxygen Isotopes in Nature and in the Laboratory

Harold C. Urey
University of Chicago

In this paper a review of the uses of isotopes is given, particular mention being made of the applications to tracers, the determination of geological time, and the identification of the remains of living organisms, plant and animal, from the difference in the isotopic abundance of the carbon isotopes. But the one new development which is mentioned in this lecture for the first time is a report of the first determinations of temperatures in which animals lived in past geological ages—in particular, the Upper Cretaceous of Hampshire County, England. These deposits make up the famous chalk cliffs of Dover. Embedded in that chalk are fossils of organisms which lived in ancient times, 60,000,000–70,000,000 years ago. Geological evidence leads geologists to believe that the temperature of this sea was perhaps as warm as the tropical seas of the present time.

This method depends upon the abundance of the O^{18} isotope in calcium carbonate, which is the chemical compound laid down by corals and many shellfish. The amount of O^{18} present in the oxygen of calcium carbonate is different from the amount of O^{18} present in the water in which it is deposited. The difference is rather small. The ratio of O^{18} to O^{16} in nature is about 1: 500, and if this is the abundance in sea water, the abundance in calcium carbonate is about 1.025: 500. This amount depends upon the temperature in which the calcium carbonate is deposited from sea water, the difference amounting to approximately 0.44% between 0° C and 25° C (32° F–77° F). If, therefore, the abundance of the oxygen isotope can be determined with sufficient precision, it is possible to tell at what temperature an animal lived from the isotopic composition of its shell. This is not useful at the present time, since mercury thermometers are far more convenient, but there is the possibility that this will be a very durable thermometer which may have been buried for hundreds of millions of years without being destroyed.

It has been necessary to increase the precision of mass spectrometers used for the measurement of relative abundances of isotopes by approximately a factor of 6 in order to measure 1° C. It has also been necessary to prepare exceedingly pure samples of carbon dioxide gas in order to secure such high precision. The results show that the Upper Cretaceous of England contains, animals known as belemnites, which were similar to the modern squids, which lived between 18° C and 27° C (64° F–81° F). It is not possible to draw too definite conclusions in regard to the climatic conditions of these ancient seas, for only 6 samples have been investigated in order to estimate the climate over 10,000,000 years, but this work does give us a method for measuring past temperature conditions on the surface of the earth. The problem is not easy and is subject to many errors, just as other geological measurements are, but for the first time a quantitative measurement of this important quantity is available.

The problem ahead is very great indeed. To determine the temperature of the earth at the present time by our usual thermometers is a substantial problem. But to determine the temperatures of the earth through a hundred million years or more, using a very complicated recording thermometer, will be difficult. It will be necessary to be very discriminating in regard to results secured. We cannot expect that every fossil has preserved an exact record of the temperature at which it lived. We hope to find a limited number of fossils which have preserved this temperature record. (The full article on which this abstract is based appeared in *Science*, 1948, 108, 489.)

Science, Psychiatry, Survival

Kenneth E. Appel
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Man today is living in an age of revolution. It is a period of tension, conflict, instability, and uncertainty. The sources of this are not wholly in the present, but partly in the training and education people have received, in home and school, and in 19th-century science, which emphasized matter, mass, motion, energy, force, power, struggle, and the survival of the fittest.

In industry, man became a *unit* of matter and energy—a *thing* to be moved by strength. Philosophy ended in hedonism and Marxian materialistic dialectic. Economics enunciated the doctrine of *laissez faire* and free enterprise.

Modern technology has produced new conditions of life, economically, politically, and internationally. It has developed big business, monopoly, and urbanization. This has created new conditions in the social relationships of people: new social classes, unions, aggressive reactions against discontents, and strikes.

The effect of 19th-century science has been to stimulate the primitive aggressiveness and fears of men, their needs, hopes, fears, ambitions, hostilities, and guilts. What are we going to do with these impulses of hostility and destructiveness, increased by recent wars, and economic insecurity, with which our institutions in their present form do not adequately deal? *Increased* mobilization of anxiety and aggressiveness is shown in our society by the increasing burden of mental illness, juvenile delinquency, divorce, alcoholism, social and economic instability.

Many people have been crushed by our materialistic, schizophrenic civilization—schizophrenic, because it has emphasized separateness, exclusion, isolation, instead of relatedness, wholeness, balance, and cooperation. Education has been schizophrenic—split in grooves, unrelated. Education has been chiefly in specialties, with little training for citizenship, grounding in the values of life, the relationships of people, communities, or nations. There is insufficient instruction on the sources of conflict and dissatisfaction in oneself and others, with inadequate cultivation of responsibility to others and to social "causes."

Psychiatry, with its knowledge and means of therapy, offers much that is vitally important for this troubled world. It does not cure people by thinking of them as masses of molecules in motion, but by considering them as personalities with dignity, as people with feelings, needs, desires, and ideals.

Modern psychiatry finds the moving forces in human beings in two alignments—orientation toward self *and* toward social relationships. The child absorbs social attitudes with his mother's milk. Parental attitudes of kindness, warmth, tenderness, tolerance, and patience facilitate an implementation of the social forces. Impatience, undue restrictions, indifference, domination, and rejection plant in the child social attitudes of inferiority, withdrawal, or rebellion. The concept of maturity represents a synthesis of the two forces and provides the only acceptable adjustment for individual satisfaction, social contribution, and acceptance. The essentials of maturity are known today. (These essentials are discussed in the body of this paper.)

Psychotherapy, through contact and experience with another individual (the psychiatrist), affords free expression of the malignant intensifications of fear and hostility and, through discussion and understanding, enables reorganization of the constructive forces of the individual to take place. There are two fundamental elements in psychotherapy: release of the emotions and clarification. Of the two, the feeling reorganization is by far the most important. The "truth-serum" facilitates this release and enables the patient to say just what is on his mind. Think what it would mean if the foreign ministers were given this serum in conference. It would define and clarify issues and situations, and we could all act accordingly.

Parliaments are for society what the psychiatrist's consulting room is for troubled, sick individuals. Troubles can be thrashed out in both places. The United Nations is serving a world function in the same way. We are far better off psychiatrically with it than without it, with all its difficulties. It is far better for Russia to be working off her objections and "Noes" in public than if they were reserved for the diplomatic consulting room. Newspapers perform a great public function in the same way when they present things realistically, without warmongering, vituperation, and misrepresentation. It is wholesome for Russia to be expressing herself in *Tass* and *Pravda* and for that to be reported in our press.

Institutions are society's hereditary machinery for facilitating social action. They are expressions of forces in men. These forces are for freedom and individuality, control and sociality. Both forces are in all individuals and in all societies. We must not therefore think in terms of either-or. It is not a question of individualism or socialism, *laissez faire* or control, communism or capitalism, totalitarianism or democracy. Both tendencies are in all of us and all nations. Neither tendency can be eliminated by legislation, pious wishes, or denunciation.

The same attitude that the wholesome parent adopts toward the belligerent or nonconforming child, and psychiatry shows to the patient who is suffering from emotional excesses, should be adopted toward nations suffering from nationalistic, adolescent struggles in maturity. All this involves contact. Technology through the airplane and radio has forced intimate *contacts* with strangers and foreigners, with whom we must develop understanding if there are to be satisfactory social relationships. We are applying the institution of frontier, pioneer individualistic nationalism and sovereignty to international relationships, which require different tools. Will these contacts be on primitive, tribal, childish bases of fear and hostility, or will they be channeled through principles of maturity and the attitudes psychiatry has found effective—repeated contact, time, infinite patience, understanding, tolerance for difference, and respect for historic and economic evolution? Destiny is not something wholly visited on us, but is in great part our own creation and responsibility.

The present conflict of nations will not be decided alone by materials of war, but by dealing with our own discontents and devoting our technological genius to the alleviation of our own social and economic conflicts and the creation of a more satisfying, secure, and indestructible way of life. Sources of irrational fear and hate must be recognized. Setting our own house in order and understanding our own and others' irrationalities will add immeasurably to our confidence, power, and security.

Science and UNESCO in World Affairs

Detlev W. Bronk
National Research Council

Medical Research: Operation Humanity

A. C. Ivy
University of Illinois

Modern medicine is one world-wide profession which pursues the same humanitarian aims and uses essentially the same methods everywhere. Amidst havoc and conflict, medicine is now the only scientific agency which knows no distinction as to friend or foe when disease and suffering are at issue. It is generally agreed that the prolongation of life and the alleviation of suffering due to disease has been *the greatest gift of science* to man during the past 100 years.

This achievement has magnified some old and has created some new problems. The problems of degenerative disease and old age and of population and hunger have been magnified. The problem of biological warfare has been created. The unifying principle of the humanitarian spirit of medicine, science, and the humanities provides a solution of these problems. The cooperative efforts of all who have an interest in the spiritual and material welfare of man will be required for the success of this operation for humanity.

Super-High-Energy Accelerators

Leland J. Haworth
Brookhaven National Laboratory

New Worlds for Study

James Hillier
RCA Laboratories, Princeton, New Jersey

The use of short-wavelength electrons and high-quality electron lenses now enables the scientist to surpass the resolving power of the light microscope by a factor of more than 100, but the resolution obtained in many specimens is determined more often by the contrast provided by the specimen than by the resolving power of the instrument. For the wide range of usefulness of the electron microscope to be fully appreciated, it must be understood that it is not a measuring instrument but a means of extending man's sense of vision to permit the detailed examination of solid materials with structures in the range 0.001–$10\ \mu$. Thus, for specimens which are heterogeneous to the limit of the instrument, the amount of available information has been increased potentially by a factor of 10^6. This is, in effect, a vast and complex new world in which it will be possible to use our sense of vision. Knowledge of this world will come gradually and only after a backlog of experience in it has been accumulated.

The Human Frontier

Roger J. Williams
The University of Texas

The greatest lack in the world of science today is an adequate knowledge of what people are like—ourselves—real human beings. During the next 100 years the physical sciences will continue to thrive, but the most significant developments will be in the realm of human science. Scientists from different disciplines are cooperatively studying atomic energy; others cooperatively study the stars; others study the bacteria and viruses. *But there is no place or organization in which the necessary scientists cooperatively study human beings.* This is a job calling for the cooperation of anatomists, physiologists, biochemists, and psychologists, as well as social scientists. If we leave out of the cooperation the anatomists, physiologists, and biochemists, we have left out the very ones who can collectively do the most—the ones who are best equipped to use the magnificent tools and methods that natural science has developed. If we leave out individuality in our calculations, we automatically eliminate the possibility of solving some of our most acute problems.

Elementary Particles of Physics

Carl D. Anderson
California Institute of Technology

Researches, past and present, in that important and fundamental field of physics which deals with the properties and relationships of the elementary particles of matter are discussed.

By elementary particles is meant those particles of matter which one finds when any material substance has been broken down into its simplest constituent parts. They have been designated as the "building blocks" out of which all matter, living and inert, is composed.

Up until 1932 scientists had succeeded in identifying two such elementary material particles, the electron and the proton. Then, in rapid succession new elementary particles were discovered: the neutron and positive electron in 1932, the positive and negative mesotrons in 1935, and in 1947 the mesotron was shown to exist in at least two different forms which have widely different properties.

The situation at the present time is characterized by a tremendous boom in activity. New discoveries are announced in the scientific journals almost monthly. Most of the new results are being found in studies of cosmic rays.

The novelty and intricacy of these new phenomena have been so great as to catch the physicist entirely off guard. The actual laboratory findings have proved themselves in their beauty and complexity to surpass even the limits of the physicist's powers of imagination.

He has been forced to give up such ideas as the permanence of the elementary particles, a notion which had previously been basic in his thinking. Elementary particles are continually being created and destroyed. They undergo transformations which spontaneously give rise to other types of elementary particles.

The physicist is unable to state even how many elementary particles of matter there are, let alone to speculate toward an understanding of the implications of these new findings.

How the physical world will look to the physicist after he has succeeded in uncovering enough of those facts so they can be arranged in a logical and understandable theoretical framework no one can say at the present time. All it is possible to say is that he is literally walking into a new and strange world. What the effect on men's lives will be of the exploration and cultivation of this world certainly no one can foretell.

The complete broadcast of "What Hope for Man?" is available from the Town Hall, Inc., New York 18, New York, at 10 cents a copy. Participating in this Town Meeting of the Air on the evening of September 14 in Constitution Hall were Brock Chisholm, director general of the World Health Organization; Fairfield Osborn, president of the New York Zoological Society; Harlow Shapley, director of the Harvard College Observatory; and Edmund W. Sinnott, president of the AAAS and director of the Sheffield Scientific School, Yale University.

A Centennial Volume containing the complete Proceedings of the September 13–17 meeting is planned for publication during 1949 under the editorship of Dr. Sidney S. Negus, president of the Virginia Academy of Science and head of the Department of Chemistry of the Medical College of Virginia. Dr. Negus has also for the past few years been in charge of the Press Room at the annual meetings of the AAAS.

***Note:* As arranged earlier, the next meeting of the Association will be held in New York City, December 26 through 31, 1949. There will therefore be *no* meeting of the Association during the remainder of 1948.**