

Physics and social change

Our science grows by correcting faulty theories, not by idolizing them. Society, in the same way, should see its present customs as jumping-off points, not as fixed institutions.

George E. Brown Jr

We are a society in transition. Nearly all of our values and institutions appear to be shifting around us. Can physics help us understand the transition? The answer for me is clearly—yes. There is something unique in the history and philosophy of science, particularly physics, among all aspects of human culture. Physics welcomes change and knows how to use it. Certainly the experience of physics should help us to understand the nature of the transition we now face and to direct it for Man's benefit.

From general to particular

For present-day physicists, and particularly the current generation of new PhD's or about-to-be PhD's, the phrase "society in transition" has a very personal and special meaning. They see this transition as a time of decrease in demand for their knowledge and skills, and a concurrent lowering of the prestige that they have enjoyed, in the ranks of academia as well as in the eyes of Government funding agencies, for a generation. For them, the question of the "relevance of physics" is one that requires the most intense form of soul searching, for it involves their own sense of identity and worth.

I am reminded very much of the observation of a great scientist, the anthropologist Robert Redfield, who spent many years studying primitive societies as they faced the impact of civilization.

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In his book, "Peasant Society," he noted:

"In societies which have experienced considerable change of life conditions we shall find . . . kinds of human careers in which expectancies are regularly created only to be regularly defeated. We shall find kinds of people who are taught to look forward to a career which they are not allowed to fulfill . . . The ends of life become obscure . . . People develop wants whose satisfaction brings no satisfaction."

In a sense physicists, scientists of all kinds, workers in all of the so-called "knowledge industries," are now caught up in a special modern example of that kind of problem, one that results from the very success of their efforts to create new knowledge. They see themselves made obsolete—particularly if they identify themselves with a static role or a static knowledge base.

What do we do about it?

Let us use this situation as an opportunity to reexamine ourselves and our commitment to physics and to science, and to appraise our role as human beings in a rapidly changing culture and world.

If physics students are going to perceive themselves as primarily "physicists," if their egos are going to be defined by the term "physicists," then they will probably perceive the sudden and irrational reversal of opportunity, prestige, status and income for "physicists" as the destruction of their egos

and their world. They will feel justified in their frustration, in becoming bitter, in attacking the individuals and institutions that led them down this path or the forces they perceive as having destroyed their hopes of achieving their identity as physicists. If, on the other hand, they perceive themselves most importantly as whole and unique human beings who also happen to be fascinated by physics and its contribution to Man's intellectual and cultural growth, then they can survive this blind and temporary bureaucratic misallocation of resources.

As a matter of general principle, I believe the channeling of resources for physics research and teaching into those areas most compatible with the needs of particular Government bureaucracies at a particular time in history to be, in the long run, detrimental to physics. And I certainly do not exclude Congress and the Pentagon from the scope of this comment. Such channeling does not necessarily provide for the development of the science in the subject areas most important for the total good of society. Nor does it direct the effort of physics to those boundaries of knowledge most ripe for further significant breakthroughs. Only individual physicists, or the community of physicists led by their own curiosity and insight and guided by their own sense of social responsibility, can make these decisions—not politicians and bureaucrats.

We need not dwell here on the close relationship that existed between the development of the scientific revolution,

Who is George Brown?

A member of the US Congress from 1963 to 1971, George E. Brown Jr started out to be a physicist. He received his BS in physics from the University of California at Los Angeles and, after World War II, did some graduate work in physics.

Brown's studies branched out into industrial relations, adult education and political science. He has worked as a power-station operator, civil engineer and banker. In politics since 1954, he has been a Monterey Park City Councilman, the Mayor of Monterey Park and a member of the California State Assembly, as well as the representative of the 29th Congressional District in California. The Committee for a Sane Nuclear Policy selected him to receive its Eleanor Roosevelt Peace Award in 1967.



with physics and astronomy in the forefront, and the industrial revolution. Those Western countries that most successfully exploited the fruits of the new technologies emerged from that revolution in science as world powers. On the structure of Newtonian mechanics arose not only a great scientific world view but also a great surge in mechanical invention and in industrial productivity. Nineteenth-century electrical technology, developed on the base prepared by physicists Michael Faraday and James Clerk Maxwell, then led to the era of modern atomic physics and brought us to the men who have made headlines in our own time.

It was, undoubtedly, the tragedy and the drama of World War II that gave physics and physicists popular attention, political importance and the resultant increased share of public resources. After three centuries in which the impact of physics was largely on Man's symbolic mental structures, it was the impact of an atomic bomb on real structures and real people that largely brought about this change.

Also out of World War II, in what has been called the greatest mobilization of scientists and technologists in history, came a cornucopia of great technical developments, which created the new industrial face of the mid-century. And to match these developments came new governmental structures—the Atomic Energy Commission, the National Science Foundation, the National Aero-

navics and Space Administration and many others—to shape the future of physics with the power of public dollars. In a rapidly changing modern world, with the major changes so obviously shaped by science, a science with physics in the vanguard, it appears strange that today we can even raise the question of the relevance of physics for a society in transition.

Two faces of change

Examine for a moment some of the factors that make it appropriate to describe our society as one "in transition." Most important are the increases in knowledge, increases produced by the methods of science. The great body of human scientific knowledge is not only growing, but growing geometrically. And the technology for processing, storing, retrieving and disseminating that knowledge has likewise increased geometrically. A result of this knowledge has been a great increase in the production of people and things; world population now doubles in 30 to 40 years, energy and raw-materials usage doubles every 10 to 15 years; output of mechanical products, and waste, increases at the same pace. In developed industrial societies this increased material productivity holds the promise of freeing Man from drudgery and deprivation in the near future. In a rationally organized world there is the same promise for all societies in a somewhat more distant future.

This is one level of change, one aspect of a society in transition. At another level, we find that the great increase in knowledge, and the power and material productivity resulting from it, have not created the conditions of happiness that we, perhaps, expected. In many cases it appears almost as if the opposite is true. I will not attempt to catalog the cultural ills that justify my statement, but instead quote Jerome Wiesner, Provost at MIT, in testimony before the House Committee on Science and Astronautics last year:

"... at the same time that technology emancipates man, freeing him from the necessity to slave at manual labor for a bare subsistence and promising him the opportunity for fulfillment as a truly free human being, it threatens to dehumanize him even more completely than the often uneven struggle of earlier times. This is why so many of our fellow citizens feel so cheated, so alienated. Many aspects of modern life contribute to this defeat of the individual; the size, crowdedness and inhuman quality of our cities, the disorienting rapidity of change in modern society, the threat of nuclear destruction, the inability of the educational system to prepare citizens for life in our complex society, the social inequalities and other accepted modes of behavior which violate our basic ideals, the fantastic advances in communication that saturate us all with a confus-

ing array of information and submerge personal creativity in mechanically reproduced art and music. In other words, we are confronted with a frightening chaos of an unwise and unmanaged exploitation of our new found powers."

We have these two contrasting aspects of change: a great and beneficial expansion of Man's knowledge horizon coupled with the development of an omniscient technology on the one hand, and the antithesis, the major disruptions of society resulting from Man's inability to organize and control himself, his institutions and his symbolic systems, on the other.

Contemplating this situation, I am led to analyze in terms of the dialectic framework, to seek an understanding of a new synthesis on which we could continue the development of human culture. In following this course my thinking has been illuminated by the entire history of physics—a history of the effort to understand the reality of time and space, matter and energy.

J. Robert Oppenheimer expressed this view in his Whidden Lectures in 1962:

"In our lifetimes we have seen, in a limited area, (and he was referring to physics) our beliefs and our experience radically altered—the popular word is revolutionized, but that is not quite right, for they have been deepened and changed, but not completely overthrown. I have the impression that a general awareness of this and a general experience of it may be of some use in dealing with human problems in a time when the world is changing so rapidly."

I shall try here to indicate how Man's most fundamental views are being "radically altered" not just in the limited area of one scientific discipline, but in ways that involve the nature of his own being. For it is out of this analysis that a new synthesis may come.

Directing change

The current literature is filled with analysis of the implications of this polarity of change. Max Way, in an article in the April issue of *Fortune*, analyzes what he calls the "knowledge-action spiral" at length. He notes that "Many sensitive and enraged young people blame knowledge for corrupting action. The natural sciences are denounced for pandering to gross materialism." Way defends the right of science to follow its own course, "free of direct social control" that might try to channel science toward solutions to specific social problems: "The belief that modern society can readily order up whatever kind of knowledge it 'really wants' is part of the utopian illusion."

René Dubos, one of the most re-

spected environmentalists in the US, would take a much stronger stand in controlling the adverse results of Man's expanding technology. In *Psychology Today*, February 1971, he says:

"Man should not try to conform to the environment created by social and technological innovations; he should instead design environments really adapted to his nature. He should not be satisfied with palliative measures treating the effects of objectionable conditions, but instead change the conditions. Now that scientific technology has made us so powerful, and so destructive, we must try to imagine the kinds of surroundings and ways of life we desire, lest we end up with a jumble of technologies and counter-technologies that will eventually smother body and soul."

Dubos's argument moves us in the right direction. And he raises important questions: What is Man's "nature" for which we should design environments? What are the "kinds of surroundings and ways of life we desire"? What "soul" does he fear may be smothered? Through these questions we will produce the synthesis for the new age of Man. And it is on these and similar questions that we should dwell for a moment in seeking to understand the nature of a society in transition.

Man's "nature," his "soul," can be perceived through the goals and values that direct him, and the ways these goals are shaped and changed. The institutions created by Man's culture reflect these goals and values; it is in his cultural institutions that Man tries to give meaning to his life, to establish his identity, to answer the questions: Who am I and how do I relate to the real world I perceive around me?

Throughout the scientifically oriented postindustrial world a process of soul searching is now going on that puts in question all of the cultural institutions and the symbolic systems of modern civilization. A sense of crisis has compelled us to this searching. Many of us have become fearful and alienated from the fruits of our presumed power and success. Many of our children seek a new culture and a new consciousness of life's meaning and purpose—and some speak a language strange to us.

Survival versus fulfillment

Man has always shared with all other life the need to survive; this need drives him to achieve material security and the power to resist threats from other forces, natural or human. But Man, unique of all life forms, has achieved a new dimension of being. Not just intelligence, the use of a brain, but self consciousness, an awareness of separation from the rest of nature, a sense of "being" and of that which is "not

being." And the simple consciousness of this polarity between Man and nature, between "being" and "not being," has driven Man to use his brain for another constellation of needs apart from those of security and survival.

This second great constellation of human needs has been the primary force behind Man's creation of all his symbolic and abstract systems; his language, religion, science and art; his efforts to create a "heavenly city" that would reconcile all human problems under one framework of divine law; his efforts to create a "unified field theory," which would reconcile all physical phenomena within a framework of natural law. We may call this constellation of needs Man's "consciousness expanding" needs, his needs for knowledge, for growth, for self-fulfillment.

Many physicists have tried to grapple with the reality of too many physics students for the opportunities likely to be available to them in academic, governmental, or industrial job markets in the immediate future. And I commend the various physics societies on their search for expanding opportunities for physics in such fields as the environment, health, nuclear technology, computers, oceanography, astronautics, and even the social sciences. Training in physics is, I have always felt, adequate qualification for entering any field whatsoever, and I have regretted the narrowness of outlook that failed to appreciate this.

Rather than explore this view in connection with the present, let us go back in history a minute to suggest the versatility of the good scientific mind of John Locke. He was educated at Oxford in medicine but refused to accept a degree until he was 42 and already a member of the British Royal Society, because he considered the medical curriculum antiquated and useless—irrelevant, we would say today. He was in the forefront of the scientists of the time, for his work in medical research as well as for his work with Robert Boyle, the chemist; Locke edited the "General History of the Air" after Boyle's death. History, however, records Locke as one of the greatest political philosophers of all time, one whose ideas deeply influenced the writers of the US Constitution and still influence political thinking today.

But my purpose here is not to dwell on the present job picture in physics. Let us simply note that US government support for all science, including physics, after growing at a rate of about 15% per year for a generation has now leveled off, at least temporarily. Funds for university research grants and fellowships to support graduate training are down substantially. Jobs in teaching and research for PhD's in physics are

off and will continue to be in short supply in the near future. This has been well documented in numerous reports and articles. According to *Fortune* magazine, in a March article, "The Senseless War on Science," total Government expenditures for science have declined, in real dollars, by more than 20% since 1967. Although this year's Government science-and-development budget still stands at a substantial \$15 000 million, according to the article, the decline in funds has been a hard blow for the country's one-half million scientists and one million engineers. In the northeastern US and on the west coast, newspapers are full of stories of young physicists driving taxis. So says the *Fortune* article.

The relationship, the balance achieved, between these two sets of human needs distinguishes the type and quality of human cultures—both through history and across the human family at any one point in history. A major disparity or imbalance in the efforts within a particular society to meet one or the other of these sets of needs may produce, at one extreme, a society of rich and powerful barbarians or, at another extreme, a society of impoverished and defenseless monastics. A proper equilibrium may provide us with the synthesis needed to resolve the problems of a society in transition.

Those needs that relate to security and survival are served by Man as producer and consumer, as organizer and user of power, as master and servant. They have been met generally in ways characterized by competition and conflict, by hierarchy and bureaucracy, by specialization and functionalism, by reductionism and atomization for the sake of efficiency. But most importantly, these needs exist and are satisfied within a system that has definable limits—the Man-environment system. Psychologically and physically Man can be surfeited, and even destroyed, with the excesses of consumption and use of power. And as we see more and more clearly, Man's environment can be exhausted and destroyed by his success in controlling and consuming. The drive for security and survival through power and consumption becomes counterproductive at these limits, limits already approached or exceeded in some classes and societies.

That second constellation of needs is served by Man as human "being," by the extension of his consciousness and awareness. The pursuit of these needs is characterized by the individual's search for knowledge, creativity and fulfillment, by love and cooperation, by spiritual striving, by this same individual's effort to understand the universal polarity, by mystical or logical pursuit of the nature of "being." But again,

most importantly, and in contrast to security-survival needs, these wants cannot be satisfied, they cannot produce surfeit, because they exist within a system that has no limits.

History as process

And where does this lead us in our search for a new synthesis, and for an answer to the earlier question about Man's nature? The striving for survival and security appears to fail as the continuing dynamic force in human cultural evolution, because it approaches finite limits, it becomes saturated, it produces satiation. On the other hand, the symbolic systems of science, art, philosophy, and religion in each historical time and culture produced by the striving for consciousness-expanding goals, have proven to be bound by time and culture, unable to survive the reality of other times and peoples. No particular symbolic system appears able to contain and satisfy all of Mankind's striving. And frequently the conflict over symbolic systems has created that condition best described in the words of Milton, "Chaos umpire reigns; and above him, high arbiter, chance governs all."

We see then that it must be the *process* of seeking to meet his "consciousness expanding" needs, not the result, that defines Man. The creation of abstract mental structures that best represent the reality of his world and time, that give significance to Man's existence, are his universal characteristics. From these abstract structures are crystallized human institutions to nourish and guard the symbols. Religious insight is nourished in the church; political wisdom is nourished by the state; scientific knowledge is nourished in the schools and universities. Rarely are these structures and institutions the same at different places and times. But the *process* is common to all times and places.

The process of structuring the universe, because it is process, demands change. Our new perception of Man must, therefore, value change and must be concerned with adapting Man to the reality of constantly evolving symbolic structures, rather than with those that are final and immutable. Similarly, the institutions that embody these symbols must be characterized by new modes of organization, modes that actuate change rather than stultify and inhibit it, as is the common case today.

Our attitude toward change in the past has been conditioned by the fact that it was largely defined and perceived in terms threatening to the symbolic structure and institutions that gave us survival and security. Hence our fear of change. But as we reach the stage where this set of goals is no longer

threatened, and the process of change is translated into the growth of our own perception, knowledge, awareness, and consciousness, we can experience change as joy—the joy of new discovery, which has always been the mark of creative science.

I have been trying to describe the nature of the changes at work in our postindustrial culture, and to set them in the framework of the dialectic process. We have seen a great acceleration in the accumulation and use of knowledge, largely translated into applications of power over Man and nature for purposes of security, in the case of the state, and the production of material commodities, in the case of the citizen. I see these changes proceeding in accordance with the dynamics of our culture almost without thought and certainly without integrated planning and control because they are novel to human experience. From them results a proliferation of secondary effects that are harmful to Man's environment and to his physical, social and spiritual life. A growing awareness of this thoughtlessness has resulted in a multitude of different reactions: frustration, alienation and withdrawal at one extreme; increased planning, control, direction and development of counter-technologies at the other.

Man seen as process

And emerging from this process, in an almost classically dialectic manner is, as we have noted, a new concept of Man, which I hold to be the most important aspect of the transition of our time. In this new view primary values and goals are not centered on the power-and-security constellation of needs, but are centered, instead, on Man as *process*, as Man becoming New Man, reaching out for new understanding of being, of consciousness. The main characteristic of Man's history is seen as a continuing search for meaning in existence. In the slow pace of the historical evolution of past human culture, the answers of each era to this searching were translated into abstract symbolic structures—the structures of language, myth and religion; these structures, in turn, were translated into the institutions of the culture—the social order, religious organizations, economic systems and political groupings.

Humanity's greatest loyalties throughout history have been to the symbolic forms created to give meaning to existence and to the institutions that sprang from these forms. In a real sense these institutions were Man; his identity and being were established and determined by these cultural patterns.

Now we are seeing Man as defined by the *process* of creating meaning and



Brown talks with students during the 1970 election campaign in California.

order in existence. The patterns and institutions of the past are seen as successive crystallizations of the perceptions of that era, to be dissolved, or shattered, and recreated from the insight of a new generation of perception.

Evolutionary development is not foreign to our thinking in biology, or in connection with the social, economic, and cultural aspects of primitive societies and, particularly, not foreign to the history of physics. But when we examine our own cultural system, we tend to perceive it always as the highest, or the best, if not the final and perfect, form of human experience. We therefore tend to defend its current beliefs and institutions against all efforts at change, whether from within or without.

Seeing Man as process solves many problems and, of course, creates many new ones. We may now see that the purpose and goals of life are not to be confined or measured, in operational terms, by acquisition of things or of power or status; that the dynamics of our culture need no longer be an obsessive drive to possess, to produce, to consume. We may now place Man and his total intellectual and emotional growth at the heart of our culture, not its periphery. Our mastery of material things

can be seen as a tool to the mastery of ourselves, not as an end in itself. The concept of Man in balance with nature, not in conquest of nature, becomes viable.

The problems arise from the need to create a process and a method for continuously reexamining and recreating Man's symbolic structures of belief and the institutions embodying them. These must now also be perceived as tools created to make more effective a person's search for growth, not as ends in themselves. The distinction is one that should be familiar to all physicists. The growth of physics is filled with striking examples of great symbolic structures of belief brought down by the efforts of the enquiring mind:

► The cosmology created by Ptolemy was brought down by Copernicus. The system of Copernicus was, in turn, revealed to be in error by Kepler; each new generation of physicists and astronomers has brought new and fundamental changes to our theories of the heavens.

► The great mechanistic system of Newton was revealed by Einstein to be less than absolute in its truth. The classical wave theory of light was, without quantum theory, inadequate to meet the tests of observation; in the nucleus, the quarks of yesterday are replaced by the partons of today.

What we can now see clearly in physics and in all other science is that knowledge progresses by establishing the error of existing theory, and that there is no end to knowledge of the universe. In the same way that space appears to be compressed and time

slowed down as we approach the magic speed of light, so it appears that ignorance expands as our knowledge grows, and that ultimate reality, if there is such a thing, is probably unknowable.

The physicist then, of all people, should be able to perceive that the system of symbolic beliefs common to a culture, just as for a science, is but a springboard to new knowledge of reality. It has significance, not for the security it gives but as a basis for the discovery of new truth and the creation of new and better symbolic structures. So it is appropriate that Man not create an identity totally bound to the static, to present beliefs and institutions, but that he create his identity around the dynamic process of growth and change in belief and institution.

In the light of all these thoughts, I urge most strongly that physics be presented, to physics students and to others, not as a route to status and security but as a road to adventure and excitement, as a path toward comprehension of the universe, as a way to better understanding of one's self as knower seeking to relate to the known, and perhaps even as part of the counterculture. We could go further and say that the discipline of physics reveals the essence of Man's adaptation to the process of change. It is, as has so aptly been said, "the continuing revolution."

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This article is adapted from a talk given in June at the Summer Meeting of the American Association of Physics Teachers, which took place in Beloit, Wisconsin. □