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EDUCATION AND THE SPIRIT OF SCIENCE.

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THE EDUCATIONAL POLICIES COMMISSION REPORTED IN ITS POSITION PAPER THAT A MAJOR OBJECTIVE OF OUR SCHOOLS SHOULD BE TO DEVELOP THE SPIRIT OF SCIENCE IN STUDENTS. SUCH A SPIRIT OF RATIONAL INQUIRY SHOULD INCLUDE SUCH VALUES AS (1) A DESIRE TO KNOW AND UNDERSTAND, (2) QUESTIONING OF ALL THINGS, (3) SEARCH FOR DATA AND THEIR MEANING, (4) DEMAND FOR VERIFICATION, (5) CONSIDERATION OF PREMISES, AND (6) CONSIDERATION OF CONSEQUENCES. THESE VALUES CAN BE LEARNED IN CONNECTION WITH MANY KINDS OF INTELLECTUAL ACTIVITY. POTENTIAL BENEFITS TO A SOCIETY WHICH PLACES EMPHASIS ON THESE VALUES INCLUDE HIGHER STANDARDS OF LIVING AND GREATER PERSONAL FREEDOM. SUCH A COMMON SYSTEM OF VALUES MIGHT PROVIDE THE BASIS FOR STRENGTHENED INTERNATIONAL LEGAL AND POLITICAL ORDER, AND PROMOTE INTERNATIONAL STABILITY AND PROGRESS. THIS DOCUMENT IS ALSO AVAILABLE FROM THE NATIONAL EDUCATION ASSOCIATION, 1201 SIXTEENTH STREET, N.W., WASHINGTON, D.C. 20036, $1.25 FOR A CLOTHBOUND EDITION AND $0.35 FOR A PAPER BOUND EDITION. (AG)

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Introduction

In his efforts to understand the world and to control it for his benefit, man has used many methods. He has accepted as truth—or at least as a basis sufficient for action—the insights of seers, prophets, artists, scientists, and men of practical experience. Some truths have been taken to be revealed; some have been gleaned through common sense; some have been created by intuitive processes; some have been discovered by rational inquiry. Education has traditionally given credit to all of these approaches.

In the modern world the approach of rational inquiry—the mode of thought which underlies science and technology—is spreading rapidly and, in the process, is changing the world in profound ways. This mode of thought is not new in itself; it has engaged the efforts of some of the best minds for centuries. The scale of today's involvement with it, however, is new. For the first time, it is the source of livelihood for a considerable number of people, most of them engaged in the areas of science and technology. These people have presented the world with a constant progression of phenomenal successes; and, understandably, the type of inquiry which accounts for those successes is rewarded with increasing prestige. The spirit of rational inquiry, driven by a belief in its efficacy and by restless curiosity, is therefore commonly called *the spirit of science*.

The term *science* is accurate but inadequate. It does not do justice to the fact that this mode of thought relates also to questions men usually ask and answer for reasons which they think are totally nonscientific—religious, aesthetic, humanistic, literary. The spirit of science infuses many forms of scholarship besides science itself.

In today's world, science and technology interact intimately with each other. Science is commonly expected to engender technological progress; technology in turn makes possible many of the major advances of science. Because of this interrelationship, the present statement generally links science and technology. It links them for other reasons as well: because they commonly receive joint recognition as basic molders of the spirit of modern life; because they both partake of the same spirit of rigorous subjection to test and systematic pursuit of progress; and because they both derive from and depend on the tradition of rational inquiry.

This statement attempts to define the spirit of science and to relate it to education. We believe that a greater awareness of that spirit would lead educators to assign to it a larger and more explicit place among the many goals of education.

The Impact of Science and Technology Today

The worldwide pursuit and spread of science and technology are commonly recognized. There is less recognition that the values and modes of thought which underlie science and technology also are becoming pervasive in the world. Yet these values and associated modes of thought may in the long run be more important to mankind and to education than the visible fruits of scientific and technological pursuits.

The most commonly recognized manifestations of the scientific and technological revolution are the material ones. The physical accoutrements and institutions of the advanced societies have been and continue to be altered; the living standards of many peoples have risen. But much more is changed than the material conditions of life. Modern industrialized societies possess basic elements which make them unique in history. Old routines and time-honored patterns of existence have been destroyed or profoundly changed. Economic systems are modified at an accelerating rate. The methods and results of science introduce a widespread skepticism and willingness to forgo traditional ways in art and philosophy, and they both force and enable theologians to consider new ways of defending the validity and relevance of faith.

In addition, the scientific and technological revolution affects the very texture of thinking of the common man. The gulf in spirit between this age and all previous ages is perhaps more vast than the gulf in external appearances. New or modified values and attitudes, combining to produce a new perspective on life, are gaining currency in the industrialized countries. The spread of technology is accompanied by an increasing respect for utility, efficiency, and practical results and an increasing interdependence of individuals. The spread of science promotes respect for the role of reason in human affairs by demonstrating the power of the mind when used in accordance with the spirit of science. There is a tendency to be suspicious of absolutes, a respect for tentativeness, a kind of working skepticism. Science poses a clear challenge to pretensions of absolute certainty. It promotes respect for intellectual flexibility and creativity, for the ability to revise or discard old hypotheses and to form and substantiate new ones. There is also a tendency to see the world in an evolutionary frame of reference, to recognize that what exists now may not have existed in the past and that all things are in a process of becoming.

Another component of the new perspective is a paradoxical combination of excitement and apathy. Science and technology have produced so much change and so much growth of knowledge, and they promise so much more of both, that the expectation of imminent new breakthroughs is becoming a normal and almost humdrum part of life.

It is not only in the advanced nations that science and technology are spreading. They are increasingly valued wherever people value their nation's independence, prosperity, power, and prestige. They are increasingly valued wherever nations seek a higher standard of living, improved health, or better education.

Leaders everywhere seem to act on the conviction that science and technology are fundamental to realization of all these

goals. Though they may, in fact or in lip service, wish to preserve certain elements of their culture, the leaders wish also to change it in fundamental ways. But once change begins, no aspect of the culture is necessarily immune to it. Learning to read is a case in point. A people's ability to read serves certain purposes that leaders commonly seek, such as industrialization and susceptibility to indoctrination. But the ability to read brings about more changes than some leaders reckon with. It undermines the popular fatalism and inertia on which some societies rest: it promotes a tendency to seek and consider alternatives; it gives to peasants the self-confidence to face the new world and to seek change.

The most obvious result of the spread of science and technology to the developing countries has been the development of similar institutions and appearances all over the world. The same products, the same means of producing them, the same ways of organizing life so that they can be produced and used, and the same impacts on the appearance and structure of society tend to spread around the world—more industry, more hospitals, more cities, more schools, more reading materials, more people, more aged people, more electric power, more vocational and professional organizations, more scientific farming, more movement from farms to cities, more communication and transportation facilities, more (though not always more real) popular participation in government, more governmental participation in the economy.

Some of the changes accompanying the revolution in science and technology are happy ones—in particular, the higher aspirations and the possibility of a materially better life for the masses of mankind. But among the results are also a host of painful problems. Some are in the international arena; others are domestic. These changes appear to be inherent in industrialization and to affect every industrializing society, regardless of its cultural background or its professed ideology.

On the international scene the greatest concern is caused by the existence and spread of weapons of mass annihilation. Also of grave concern is the gulf between the rich peoples and the poor peoples. The population explosion—a result of a partial use of science and technology—threatens all efforts to narrow the gulf.

One of the domestic consequences of the current revolution is the growing dependence of the individual on impersonal power. In an increasingly complex economic and social structure, organizations appear to take over from persons. Problems arise which only government seems capable of meeting. An individual faces the need to recognize that some of the things he hopes to accomplish can be achieved only through collective effort. Therefore, while enjoying the benefits of collective effort, such as the conquest of various diseases and greater security in old age, he may feel increasingly powerless and ineffective as an individual.

At the same time, changes take place so rapidly that many individuals do not feel secure in the world. As a result of the demands of specialization in a scientific and technological society, the thoughtful, sensitive individual finds it difficult to see life as a whole and is often at a loss for meaning.

The disruption of tradition is another painful domestic problem. This disruption has been profound in the West, despite the native roots of science and technology there, and it shows no signs of diminishing. In the nonindustrialized world, where science and technology are generally regarded as a means of making a sudden leap into the future, their impact is still more alien and unsettling.

Among the traditions disrupted everywhere are old certitudes, particularly religious beliefs. In many instances, the result is a decline in dogmatics and an increased stress on the social, utilitarian function of religious belief. Dogmatic secular beliefs, such as Marxism-Leninism or racism, also are undermined by the

persistent demands of technological efficiency and the spread of scientific thought.

The impact of science and technology challenges traditions of family relationship as well. Among the many results are a greater emphasis on parental love, a rise in the status of women, an alteration in the concept of divorce, and a decline in the belief that prolific childbearing when young is the best guarantee of security in old age. In an industrial society, it usually takes longer for young people to enter upon an economically productive role, and the years of dependence thus added to each person's life generate problems in the status and behavior of youth.

In education, too, tradition is challenged by the scientific and technological revolution. For example, practical and scientific subjects have fought an uphill battle for inclusion in academic education along with the traditional objects of study and for recognition as a valid part of liberal education Moreover, as the practical value of science has impressed itself upon governments, they have lavished funds upon higher education to pay for research devices and for the research itself. They have thus upset a traditional balance in university budgets, placed in question the allegiance of science faculties to the university, and one-sidedly increased the glamour and financial attraction of science teaching. In the eyes of some observers, the result is a disservice to the nation, for it degrades the relative status of the humanities and social sciences and ignores the value of nonscientific creativity and thought. In the eyes of others, governments are merely responding realistically to the high costs of scientific research devices; and the growing emphasis on science represents not an unbalancing, but a correction of the balance in order that the spirit of the modern age may take its legitimate place in the modern curriculum.

In destroying certainties and challenging tradition, science and technology destroy many persons' psychological moorings.

For this reason, the problem called *alienation* preoccupies social scientists, psychologists, playwrights, and painters.

As traditions are assailed, traditionalists counterattack. Thus, in the Soviet Union, modern scientists are challenged by communist ideologists; in Afghanistan, Moslem teachers challenge secular scholars; and in the United States, the sanctity of free enterprise and of states rights is asserted to oppose change.

Thus, science and technology on the one hand arouse the expectation of a better way of life, give promise of material satisfactions, and hold forth great possibilities for the development of human potentialities. They give rise to a genuine optimism and excitement. But they also give rise to anxiety—to a gnawing apprehension of man's alleged loss of personal freedom, of certitude, of psychological security, of identity.

The Potential of the Scientific and Technological Revolution

The current growth of science and technology is perhaps not immutable. It could be halted by a cataclysmic war. This threat provokes—and justly so—great apprehensions about the spread of science and technology. As science expands knowledge, awareness grows of the frightful uses to which knowledge can be put, with man ever more efficient at carrying out the deeds of destruction which he has been perpetrating throughout history. But not even this—the most frightening of arguments against science and technology—seems capable of arresting the trend. On the contrary, fear seems to cause many men to attack the causes of fear through greater dependence on science. Evidence continues to accumulate that the best way to deal with the great social problems—especially such problems as war and violence—is to increase dependence on reason.

The spread of science and technology could conceivably be halted by war; perhaps it can also be halted or slowed by its opponents. Ideologically based dictatorships confront it with powerful obstacles. Privileged groups in many societies view it as a threat to their power. Many sincere persons lament the passing of revered tradition or fear other consequences of the continuing revolution.

Despite opposing forces, however, change seems to be sought everywhere and to be taking place everywhere. In an isolated so-

ciety, traditions may have provided a passable guide for living and a sufficient basis for the preservation of personal power. Today, however, the possibilities of a greater power, inherent in modernization, beckon to leaders everywhere; and the hint of a more effective guide for living than any rigid adherence to the past filters through to each person who comes into contact with science and technology. Among the people, there is a seemingly irresistible attraction in education, better health, an abundance of tangible products, and new techniques for doing almost everything.

Here is a chance to remove from the majority of men and women the necessity of spending their lives at physical drudgery in return for bare subsistence. Here is a promise of improved health for all, reduced infant mortality, less physical suffering, less disease, and longer human life. Here is a possibility for all men to extend their personal horizons of knowledge to a degree which heretofore has been reserved for a tiny elite. Here is a promise for limitless growth of man's knowledge and understanding.

Thus, opposition to change is outweighed by support of change—indeed, by the necessity of change. The result is a worldwide scientific-technological revolution that leads everywhere to results that are strikingly similar. It is obvious that nations are very different from each other today. This is not surprising, for their backgrounds, histories, and populations are all unique. But their contemporary cultural patterns are moving in many common directions. Whatever their ideologies; whatever their historical background; whatever their social organization; whatever the value they claim for tradition, art, music, or literature, these cultures continue to assign a growing role to the common values, common aspirations, common material goods, and common problems associated with science and technology.

The outcome of this trend is not likely to be worldwide conformity to a single culture. In particular, the mere fact of a gen-

eral trend in the direction of more science and technology does not mean a general adoption of Western culture. Many cultural traits in any society will probably prove consistent with the scientific and technological revolution and will coexist with it.

Furthermore, many traits of what is now Western culture will be challenged and altered by the continuing revolution. There is no reason to believe that the development of any culture or nation, as measured against its potential, has yet gone very far along the path of science and technology. No society is today composed predominately of individuals who are guided in most of their behavior by scientific modes of thought or action. Other bases, conscious or unconscious, seem to guide most persons in most of their activity. Even where it is deepest, the penetration of the rational spirit may still be shallow in comparison with its potential.

Leaders and peoples everywhere have been attracted to science and technology for the resulting benefits in power, prestige, standard of living, education, and health. Science and technology can provide those benefits; but the spirit underlying science and technology promises two less tangible but equally profound benefits: increased individuality and increased brotherhood of men.

The promise of increased individuality derives from the very essence of the spirit of science. This spirit can enable each person to free himself from blind obedience to the dictates of his emotions, of propaganda, of group pressures, of the authority of others. It can enable him to be aware of the influences which play on him. It can enable him to sift through the forces which act upon him and, to some degree, to determine and to become his own ideal self. There is little basis for the frequently heard assertion that science engenders conformity. Indeed, it can be contended that conformity has been produced in most ages, not by the spirit of science, but by the very cultures which produce diversity between groups. Traditional cultures are powerful mechanisms for determining the responses and thoughts of the masses of people, rather

than for eliciting their potentials for creative, individual responses and thoughts. If the world's cultures today ensure differences between groups, they have also produced a high degree of conformity among individuals. The scientific spirit might be, not the producer of conformist cultures, but rather the force making possible individualism on a previously unknown scale.

In addition, the improvement of living standards which has produced in the United States a considerable increase in popular participation in artistic pursuits may give occasion for a similar increase in other parts of the world. The spread of the spirit of science, then, might lead, not to the stagnation of other endeavors, but to greater devotion to the arts and the humanities and hence to more variety in the lives of more people.

The blossoming of individuality is one relatively neglected promise of the spirit of science; a closer community of mankind is another. The deeper workings of the spirit of science are creating, even where this end is not consciously sought, a general commonalty of values, a sort of spiritual unity among men.

Spiritual unity among nations and men has long been a prime goal among thinkers and dreamers. In the past, this goal has usually been sought through some community of values peculiar to a small group, but hopefully to be universalized. Characteristically, each community of values was founded upon a belief in a religious revelation or philosophical orientation which also was peculiar to a minority of mankind. The pursuit of unity along these lines has been perpetually frustrated, in part by the absence of a universally accepted system of values which transcended religious, philosophical, and cultural limitations.

Today, however, the values on which science and technology are based are gaining acceptance in the most diverse cultures. In this regard, the spread of the spirit of science can be an extraordinarily hopeful development. It might represent a movement toward genuine similarities of belief, thought, and action. It might

produce a new kind of community among the world's peoples—a deeper feeling of mankind's oneness than that to which the few values hitherto shared could give rise.

As men come increasingly to share these values, they may find better bases for agreement on other matters. There may well be an erosion of the feeling of group separateness and a keener sense of the brotherhood of man. There may be political and legal effects as well. Political systems are in part reflections of the values of their creators. Similarly, legal systems are embodiments of systems of value. Thus it is possible to hope that a shared system of values might provide the basis for actions to strengthen the international legal and political order, and hence to promote international stability and progress.

Many approaches to peace or the prevention of war are tried today. They include international organization, power politics, foreign aid, and the preaching of brotherhood. All are valuable, but perhaps it would be at least as hopeful to look for the promise of peace and brotherhood within the first major system of values which has shown that it can penetrate any culture.

Therefore, aware of the apprehensions aroused by the penetration of the scientific spirit, we conclude that the hopes it offers so greatly outweigh the drawbacks as to justify a major recommendation: that a general worldwide fostering of the spirit of science is wise. This conclusion has implications for American schools and for American foreign policy.

Recommendations

The schools should help to realize the great opportunities which the development of science has made apparent in the world. They can do this by promoting understanding of the values on which science is everywhere based. Although no particular scientist may fully exemplify all these values, they characterize the enterprise of science as a whole. We believe that the following values underlie science:

1. *Long. .g to know and to understand*
2. *Questioning of all things*
3. *Search for data and their meaning*
4. *Demand for verification*
5. *Respect for logic*
6. *Consideration of premises*
7. *Consideration of consequences.*

These values are not stated the way more traditional values are stated. They do not contain some of the traditional value words, such as *love, honesty, beauty,* or *patriotism.* But neither are they necessarily in conflict with traditional 'alues. Like all values, they are guidelines for belief and hence for action. Some of them merely define traditional values; for example, the demand for verification is nothing other than an approach to, and a profound respect for, honesty. Some of them undergird, and

almost make inevitable, values which are often expressed as self-evident truths; for example, an awareness of consequences makes love of one's children and responsibility to one's neighbors essential. And, like other sets of values, they have the defect that neither individually nor jointly do they provide a fully adequate guide to action; in many concrete human situations, various values, all cherished, are involved, and the choice of action involves an ethical compromise. The values of the spirit of science express the belief that the compromise is likely to be better if based on thoughtful choice; in this respect they differ from those value systems which hesitate to submit all problems to reason. Perhaps they differ from some other sets of values in the degree of reliance they place on the individual. Instead of insisting on his acceptance of certain values favored by men or groups allegedly wiser than he, the spirit of science insists that he make up his own mind. In this, the values of science are the most complete expression of one of the deepest of humane values—the belief in human dignity.

By their very nature, these values cannot be acquired through indoctrination. For the spirit of certainty upon which indoctrination rests is contradictory to each of them. Dictatorships do not make progress in knowledge and capability in those areas in which they insist that the truth is already known. Consequently these values, unlike indoctrinated values, are part and parcel of any true education. These are characteristic not only of what is commonly called science but, more basically, of rational thought—and that applies not only in science, but in every area of life. What is being advocated here is not the production of more physicists, biologists, or mathematicians, but rather the development of persons whose approach to life as a whole is that of a person who thinks—a rational person. The characteristics of this mode of thought merit consideration in greater detail.

1. *Longing to know and to understand*

The spirit of science is, at bottom, a longing to understand. It seeks to understand because it accepts knowledge as desirable in itself. It expresses its curiosity endlessly, recognizing that questions are infinite, answers finite. The events which surround an inquiring person pose for him the fundamental problems of why and how. He deems it a worthy investment of himself and of mankind to become mobilized in the search for answers.

2. *Questioning of all things*

There is no perfect knowledge and no perfect knower. Certainty, as a concept, is replaced by probability. All conclusions and decisions are more or less suspect; science rides on a preference for the less over the more.

If certainty is illusory, it is partly because men cannot be fully objective. Some tinge of the observer must color any observation. If men cannot eliminate this influence, they can at least take it into account. The pursuit of the highest probability of accuracy in conclusions calls on an observer to be aware of the full range of experiences within which he operates, including his own subjective, intuitive, aesthetic, and nonrational responses. These responses have their own uses and compose also part of the reality to which the spirit of science extends. They could not be eliminated even if that were desirable. A scientific thinker does not attempt to snuff them out, he tries rather to be aware of them and to understand which of them are helpful and which are harmful, which are harmless, and which irrelevant.

Here is a prime source of that attitude of modesty and humility which characterizes the general posture of the seeker after knowledge. Conscious of the uncertainties with which he deals, he must nevertheless reach some sorts of operating conclusions. He must, from time to time, act or decide, always with incom-

plete evidence, by incomplete intellectual devices, with even incomplete means of reading results. Incompleteness rules science, producing a universal spirit of tentativeness and inhibiting the development of that ferocious intolerance so often revealed when supposedly definitive beliefs are challenged.

Since scientific knowledge is tentative, all propositions are subject to being revised or discarded. Reluctance to discard beliefs is one of the most difficult problems of rational thought for two reasons: (1) A thinker himself treasures certain concepts, values, or "self-evident" truths which have served him in his own life; these he challenges only with difficulty. (2) A thinker usually depends on support from the larger community in which he works, and that community may be unwilling to examine certain values—for example, those of religious or national traditions—which his work may call into question. He may thus be confronted with a conflict between loyalty to the basic values of the scientific spirit and the practical steps necessary to advance it.

In spite of these difficulties, a thinker feels compelled to insist that the range of his curiosity cannot accept limits imposed by external authority. He examines external authority as well. There is no sanctuary for ideas.

3. *Search for data and their meaning*

The longing to know is the motivation for learning: data and generalizations are the forms which knowledge takes. Generalizations are induced from discrete bits of information gathered through observation conducted as accurately as the circumstances permit.

Much of science consists of the acquisition and ordering of data. But data taken by themselves normally have little meaning. The principal contribution of scholarship to an understanding of the world is found, not in such data, but in theories which explain phenomena. Scientists often refer to these theories or

insights which interrelate data and give them meaning as *conceptual schemes*. The evolution of these conceptual schemes is an intuitive, highly creative process. It involves seeing connections and meanings others have not seen. Here is the place for intuition and creativity in science and in all other modes of thinking which seek the same values. The process of creating new integrations implies flexibility, originality, breadth and fluency of mind, and freedom to skip from one frame of reference to another sensing new relationships and hidden meanings.

4. *Demand for verification*

Implicit in the concept of the tentativeness of knowledge and of conceptual schemes is the concept of test. Knowledge is, at best, hypothetical, and the statement of a hypothesis suggests that it is subject to test. A thinker, therefore, consciously seeks to find ways to expose the results of his thinking to test or experiment and to the play of as many other minds as possible.

Conceptual schemes may be arrived at both inductively and deductively. Unless they can be confronted with the results of empirical test, however, they are little likely to gain widespread support. The scientific spirit is therefore predisposed to the search for such test as the basis for favorable evaluation.

The search for a testing situation is itself a highly creative act. A scientist does not merely permit the evaluation of his conceptual schemes; he actively seeks it. He values the positive and imaginative creation of situations which test hypotheses, suggest new ones, promote exploration, and give expression to the spirit of excitement and adventure which suffuses the scientific enterprise. Furthermore, the creation of new means of verification may itself be a significant scientific advance.

5. *Respect for logic*

Logic is the science of valid inference. Logical systems constitute agreed bases by which the validity of inferences may be

judged. There are a number of such logical systems, and new ones are in constant process of growth. But all of them agree on the meaning of such basic concepts as consistency and contradiction.

Logic is used in connecting a thinker's concepts in a manner open to evaluation by other persons. A thinker judges the validity of inferences and deductions in terms of logic. But he recognizes also that no amount of logical consistency will make valid any inferences or deductions which proceed from inadequate or faulty premises. Mere logical consistency does not constitute an adequate appraisal of a concept, proposition, or idea. It is also necessary to ask whether the data being reviewed are relevant and necessary in the situation and whether the premises are both relevant and sufficient.

6. *Consideration of premises*

A thinker is at the center of any situation involving knowledge. As he seeks knowledge or understanding in any situation, he recognizes that he must keep in mind not only the external questions which confront him, but also internal predispositions that shape his thoughts. As he applies and develops the values of science, he does so consciously, and tries to be sensitive to his own inadequacies in that effort.

There is a limit to fruitful inquiry into one's premises and assumptions. In this effort, too, certainty is unobtainable. But, in choosing to act or conclude, a thinker does not rest assured that he has reached the firm bedrock of faith. Rather, he recognizes that he has reached the present limitations of his abilities. Humility is required, and fanaticism excluded, by the spirit of science.

7. *Consideration of consequences*

To hold to a value or to decide upon an action without awareness of its implications or its consequences is to believe or

act in partial ignorance. Awareness of implications can, like the rest of knowledge, at best be incomplete. But a rational person does not accept a value or decide upon an action without trying to be aware of its implications. He recognizes that he is, after all, part of the human race and that his decisions will have bearing on other persons and will be judged by other persons. He cannot, therefore, think of his single localized decision only, but must recognize that each conclusion or decision will reach a wider circle of influence. He must, then, think about implications and consequences, take them into consideration, and avoid actions whose backwash will be harmful. A sense of responsibility is inherent in honest thought.

This does not mean that the search for knowledge must lead only to happy results. But neither does any other value. The search for knowledge made the atomic bomb possible, but it led to that result only in the service of other values—love of country and hatred of tyranny. One would be hard put to name a value whose results, in the light of all other cherished values, have always been exclusively good.

If a single word summarizes the various characteristics of the scientific spirit, it is *awareness*—awareness of the uncertainty of man's knowledge, awareness of the extent to which the self influences one's perceptions, awareness of the consequences of one's values and actions, awareness of the painstaking modes of thought which have enabled man gradually to develop his knowledge of the world. This awareness is the basic stuff of freedom; only insofar as a man is aware of the influences upon him can he filter them and become himself, and only insofar as he is aware of the problems and modes of knowing can he help himself and others to understand the world.

Here, then, is a group of values which schools can promote without doing violence to the dignity of the individual. Here are values which are not intended to be accepted on the basis

of external authority. On the contrary, they are themselves frankly intended to be challenged. The school here envisioned would have failed in the case of any student who has never questioned the desirability of these values. It would have failed in the case of any student who has never compared the various bases which different men deem sufficient for knowing or for acting. The view of teaching as the indoctrination of superior knowledge and wisdom here gives way to a concept of teaching as promotion of the development of the learner from within.

In this way, schools can be profoundly concerned with values and ethics in a manner fully consistent with the democratic belief in the dignity of the individual and with the scientific belief that no one—the school included—knows the final answers.

What is advocated here is not a separation of science from other aspects of life but rather the understanding that the spirit of science applies to other facets of man's existence. It fuses with many kinds of thinking that men traditionally consider distinct from it.

The view that there is a necessary conflict between the scientific and the humanistic approaches to life is not valid. When science is isolated from the moral and spiritual aspects of life it can produce the monstrosities so often feared, just as the acceptance of values on the basis of emotion and without rigorous examination of their likely consequences has often produced abominations.

The values of which the spirit of science consists should permeate the educative process, serving as objectives of learning in every field, including the humanities and practical studies. These values can be learned in connection with any kind of intellectual activity. Indeed, all parts of the educational program should reflect the unity of life. For example, any subject can be so taught as to contribute to the student's tendency both to ex-

amine all concepts and to inquire into the social implications of the questioning spirit. The thorough compartmentalization of subjects in a school is in conflict with human experience and the best interests of human development. The schools must continue to sensitize students to the aesthetic and ethical experience of civilization and should try to unify all these considerations.

It cannot be assumed that the addition of science courses to a curriculum would necessarily contribute to the achievement of these goals. Indeed, science can be so taught as to be irrelevant or even opposed to their achievement. Efforts to discourage challenges to traditional beliefs and attempts to indoctrinate are probably widespread in every school system, however advanced the content of science courses. What is needed is an education which turns the child's curiosity into a lifelong drive and which leads students to consider seriously the various possibilities of satisfying that curiosity and the many limitations on those possibilities.

Just as the values of the spirit of science can serve as educational goals in American schools, they can also serve to help orient the foreign operations of the United States government. It should be a direct aim of American foreign aid and technical assistance programs to help other nations to foster these values. This may not be an appropriate immediate objective for many countries, but without it as a long-range goal, a nation's intellectual, and hence other, resources cannot be satisfactorily developed. Two objections immediately arise. The first is related to the propriety of setting goals for other peoples. Certainly, to set goals for foreign peoples is not only contrary to the American sense of justice, it is also impossible to carry out, for the United States does not rule the countries which it aids. But in most cases the problem is not likely to arise in any more acute form than it does in economic development. All countries, however poorly endowed in mineral resources, have a vast and largely untapped potential in mental resources. Increasingly they are recognizing

that their progress—as they define it—hinges on their success in developing the minds of their people. In particular, as noted earlier, all countries wish to foster their scientific development. They themselves realize that if they lack people who master the spirit of science, they will be dependent on the creative science of other countries. To countries that wish to foster individual freedom, the relationship between the values of the spirit of science and individual freedom is evident.

The second objection that arises is that little is known about how to promote learning of these seven values. The objection is valid, but inadequate. Little is known, too, about fostering the economic development of nations; but that has not kept nations from trying—or from succeeding to some extent. That goal has been deemed important enough to justify doing the best one can with inadequate knowledge. The goal here proposed is, in our opinion, also important enough to justify trying. Indeed, we think that economic development itself calls for the achievement of this goal. Furthermore, educators traditionally have sought goals which they have known only imperfectly how to achieve. Among them are social responsibility, creativity, honesty, and patriotism. For these reasons, we do not regard the scantiness of knowledge of how to foster rationality as a sufficient argument against making the attempt. It is rather a challenge to do the best that can be done with present knowledge and to undertake the sorts of research that will enable mankind to do the job better.

Furthermore, these seven values of the scientific spirit are all quite specific educational goals. There is no reason to doubt that they can be sought and gradually promoted. Certainly the rewards for doing so might be immense.

Not only would solid progress in the direction of these educational goals yield immediate benefits such as improved standards of living and health, but also there might be found in

these developments gains in ethical dimensions which have long eluded man. Although these values are those of science, and although science is often said to be neutral on questions of value, there are many ethical implications which flow from these scientific beliefs. The longing to know and the demand for verification imply honesty, reliability, and responsibility; every practitioner of science depends on the honesty of other scientists. Each realizes that this requirement also rests on him. The pursuit of truth is impeded by a lack of mutual trust and faith.

Implicit also in these values is a modesty or humility which contrasts with the boastful self assurance of arbitrary authority. A man of science is suspicious of certainty. He insists that no concept, proposition, or belief is immune to examination and possible rejection. He is willing to challenge even the scientific approach as he understands it. Most of all, he is willing to see his own conclusions challenged. He recognizes his own failings and those of others. He knows that no observer, thinker, communicator, corroborator, or other human link in the scientific process is perfect.

It is often said that science is amoral. One may legitimately ask, however, whether the spirit of science does not have truly humane implications. What are the ethical implications of recognizing that all that is known is known by minds; or recognizing that there is no science—or art—except that which is carried by human beings; or recognizing that every human being has at least the potential of contributing to that which is known? Those who are conscious of the power of the human mind and of the vastness, if not infinity, of the fields for minds to conquer, can hardly avoid a profound longing for all minds to be developed.

Moreover, as noted above, a reluctance to accept ignorance as a basis for belief or action implies a responsibility to understand the premises and consequences of one's beliefs and actions.

But to say that a sense of responsibility is inherent in the scientific spirit is not to say that all scientific thinkers will inevitably come to conclusions acceptable to most other people. Thus, there may be some dangers in a commitment to individual freedom and in a true acceptance of the belief that no one knows the final answers. But there have been great dangers also in other commitments. The traditional morality has, after all, included such items as devotion to nation and the supposed unquestionability of certain knowledge; and acceptance of each has repeatedly occasioned misery to the world. Perhaps it would be no less safe to entrust the future to people who constantly ask "why," to people whose acceptance of the need for certain social rules derives from understanding rather than obedience, to people who doubt the finality of their own wisdom and of the wisdom of others, to people who try hard to understand the premises and implications of their values and decisions.

It cannot be guaranteed that a society which seeks the scientific spirit will avoid repetition of the inhumane acts with which history is replete. Religious wars have repeatedly been fought by men who professed belief in faiths devoted to peace. Science might be similarly distorted by scientists, but such distortion is neither required nor justified by scientific traditions. It arises, not from devotion to the spirit of science, but from failure to be guided by it.

The spread of science and technology may indeed carry seeds of a most hopeful future for man. Perhaps the most visible phenomena of international relations are nationalism, hatred, and violence. They account for the headlines, and their genuine significance cannot be denied. But there may be a deeper tide in world affairs, a tide too quiet to produce headlines but of overwhelming importance to the future of mankind. That tide is the development of a common commitment to a set of values which, in the hands of a very few persons in a very few countries

over a very short period of years, has given man unprecedented powers to perceive, to understand, to predict, to control, and to act.

The profound changes men have wrought in the world by their uses of science and technology have been for better and for worse. But the spirit underlying science is a highly desirable spirit. It can enable entire peoples to use their minds with breadth and dignity and with striking benefit to their health and standard of living. It promotes individuality. It can strengthen man's efforts in behalf of world community, peace, and brotherhood. It develops a sense of one's power tempered by an awareness of the minute and tenuous nature of one's contributions. Insofar as an individual learns to live by the spirit of science, he shares in the liberation of mankind's intelligence and achieves an invigorating sense of participation in the spirit of the modern world. To communicate the spirit of science and to develop people's capacity to use its values should therefore be among the principal goals of education in our own and every other country.