Comments and Communications

Role of the Earth Sciences in General Education

I cannot agree with Eric M. Rogers, in his discussion of science courses for general education in college (*Science*, 1949, 110, 599), that the needs of our future citizens for science education will be fulfilled by courses which only make "students understand what science is like and what scientists are like." This is much too limited a goal for the times in which we live and the long range developments that present events portend.

It is agreed that we should be concerned for the good name of science and that a more general understanding of science is necessary. This is a task that science itself must accomplish by making it possible for the average nonscientist to relate the realities of science to the realities of his own life.

Most of our potential voters in the United States will not attend college, and the majority of the remainder will be nonscientists. It is manifestly impossible to give a general background in all science to the nonscience majors in either high school or college. If it be granted, for the sake of this discussion, that a general science course is the most appropriate one for most of these students, its content should be determined by the objectives of the course. In general, these objectives would seem to be to meet the scientific requirements for democratic citizenship in our present technical age.

Before defining these goals more specifically, let us look at the world in which the students will live. The applications of chemistry, physics, and engineering have supplied the stimulus for our fabulously complex and delicately balanced industrial structure. The biologist and the medical scientist have lengthened life and made it more comfortable. Applications of the biological sciences have given us new crops with higher yields and greater resistance to disease, new strains of animals which produce more pounds of meat or milk per bushel of feed, new compounds and new products which arise daily.

Yet the chemist, the physicist, and the engineer use raw materials which for the most part come from the earth's crust, where they have been produced by geological processes. Organic raw materials depend on the soil and the rain for their abundance. We live almost entirely on the surface of the earth, in buildings composed of materials which have their genesis primarily or secondarily in or on the earth, and which are heated with earth materials.

Thus, everywhere our students turn, the basic factors in their daily lives are those which compose the physical environment. These are the weather, the climate, the terrain, the soil, the water, the biological and mineral resources. These factors, plus geographical location, have much to do with national strength and prosperity.

The United States is an industrial country. The fruits of the physical environment, and their proper use, have great influence on the health of industry, and thus on our national well-being. Only careful use, and adequate renewal when possible, will maintain our resources at an effective level. Only an informed and scientific approach to the use of the physical environment will make this possible.

In a democracy such as ours, if we expect to preserve it, the voter must therefore understand how his environment operates. He must also have a basis for understanding the role these elements play in national survival. And he should be able to comprehend the basic principles utilized in effective exploitation of the physical environment to buttress and maintain our standard of living.

Until rather recently the United States was a frontier nation. Our thinking has been geared to a constantly expanding economy. Now we have occupied all of our readily utilized area, yet our population is increasing rapidly. We are constrained, by the very nature of our national mores, to maintain a high standard of living, which in turn requires a stable economy. To do this we must use what we have with ever-increasing efficiency.

Outside our boundaries, present international trends suggest that the United States may eventually become the only effective island of democracy in a political sea of communism. In this event, the strain on our economic system will be great, since the spread of communism will eliminate a large part of our foreign trade. In any event, we face the possibility of a long period of ideological and economic stress, during which we must be increasingly self-sufficient. This is not to mention that as long as communism maintains its present attitude, the threat of war will always loom just over the horizon.

Under these circumstances, if we must restrict most of our potential voters to a single year of general science (for high school graduates) plus an additional year for most of those fortunate enough to go to college, which is more important? To give our students a liking for science? To give them a scientific basis for citizenship in the disturbed and confusing world of this mid-century? Or less modestly, to strive to give them a scientific foundation for both? I submit that the latter is the only reasonable long range goal for general science education.

In order to demonstrate better the need for such a goal, let us look at some of the national problems with which our voters and our legislators must be concerned if we expect to maintain our national vigor and an economy characterized by free private enterprise. Among them are:

1. Our national use of the land.
2. The distribution of production (which in the last analysis is dependent on raw resources).
3. The preservation and use of timber resources, and reforestation.
4. Effective utilization of our national regions of differing climate and productivity as one homogeneous national unit.
5. The water problem: control of rivers and drainage systems to prevent floods, produce usable power, and as-

sure maximum productivity of drainage areas; measures to cope with the depletion of underground water, which is now becoming of national concern.

6. More effective and more stable use of such areas as the Great Plains.

7. The soil problem: prevention of erosion and depletion; renewal of areas that have been partially exhausted and more effective use of marginal lands.

8. The problem of mineral resources: more accurate information concerning supply and demand; utilization of "marginal" deposits; a realistic national policy concerning importation of scarce raw materials to prevent peacetime exhaustion of domestic deposits which may be essential during war.

Furthermore, the nature and distribution of the world's natural resources and arable lands and their political control will have an important effect on the future of our internal national economy.

Now if our high schools and colleges were to offer students a general science course designed to meet the goal stated above, it could provide them with an understanding not only of the basic principles of science, but also of the ways in which these principles operate to produce and modify the physical environment with which we must live in harmony. The sciences which deal with the physical environment (geology, geography, meteorology, etc.) rest on the application of the fundamental laws and practices of other sciences (chemistry, physics, biology, etc.) to the problems of the earth and its biota. A general science course could as well demonstrate the workings and applications of the laws of gases through a consideration of weather as through a standard laboratory experiment in physics or chemistry. The principle of the indestructibility of matter is as well explained through the processes of weathering of rocks and the production of soil as through an experiment in chemistry. The reasoning and methods utilized in a problem in local weather forecasting, or the development of terrain, illustrate how scientists think and work as effectively as an example from the history of science.

Thus in addition to an understanding of scientific principles, the knowledge gained in such a course would show the influence of geophysical factors on the development of industry, the history of settlement and the constantly changing tides of international relations. Even more basically, it would illustrate cogently the impact of these factors on the life of the student himself and the world in which he lives, and be far better remembered for this reason. From the cultural standpoint, geology and related subjects also seem to offer one of the best vehicles for an understanding of the long sweep of human activity which leads us back to the caves of Asia Minor during the glacial period. For despite our "conquest" of our environment, the climate, the resources, and the geography of the land across which our race has moved have had much to do with where we have gone and how we have traveled. It would seem extremely difficult to understand human history, therefore, without some comprehension of the framework within which it occurs.

Lest I be accused of special pleading, let me quote the views of a distinguished scholar, the dean of Yale College, William Clyde DeVane (*Yale Review*, Autumn 1943, pp. 34–46). In discussing the high school curriculum, he wrote

> . . . the pupil should be introduced, but in no easy way, to the concepts of the natural sciences which shape so much of our thinking. A sound course in physics on one side or in biology will do this admirably, but I should recommend a course in geology, which seems to me to have peculiar advantages for boys at this age. In content, it is concerned both with inorganic nature and with life in nature. Its tremendous sweep in time gives perspective. It is an incomparable study for giving the young imaginative mind the largest conceptions of space and time, and at the same time it inculcates scientific methods and principles.

In his further discussion of an optimum general education program at the college level, Dean DeVane continued

> . . . it [the curriculum] must be as adequate for our day as the Greek and mediaeval syntheses were for their times. It must show the student the inanimate world and give him a grasp of the principles upon which it exists; it must present the panorama of history, of man's ideas and institutions, of his struggles, failures, and successes.

In view of the fact that the physical environment is the canvas on which man has painted the panorama of his history, it seems reasonable that the general science course as outlined here would meet Dr. DeVane's requirements. Furthermore, it would contain no "blocks" and no "gaps"; rather, it would be a complete and integrated fabric. The warp would be the science of the surrounding environment, which has always influenced and will always modify man's activities; the woof would be the demonstrated laws and processes that cause the environment to operate and change. From this synthesis the student could come to understand how his environment works, and that our collective interaction with it produces certain effects which must be met by cooperation with nature. The principles of scientific thought and investigation then become an integral part of the subject matter, and are brought recurrently to the attention of the student by every change in the weather, the sight of a new or strange terrain, or an item in the daily newspaper.

Moreover, as the work week has shortened, many more persons have leisure to travel, to seek recreation in the out-of-doors, and to visit our state and national parks. Surely the cultural value of some knowledge of the origin of scenery and an understanding of the reasons why the various regions of our country demonstrate such different features and development should not be ignored in the preparation of an educated citizen.

Except for the unfortunate pattern of science teacher preparation and a certain amount of academic timidity, there is no reason why such courses cannot be offered at varying levels of complexity, to students ranging from junior high school to college. The institution or the department that has the courage to discard traditionalism and approach general science education in this way may find it difficult, but infinitely rewarding. The students who are so fortunate as to be enrolled in such a course will receive a stimulating insight now granted to few, and a firm basis for better living and more understanding citizenship.

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