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"And on the seventh day God ended his work which he had made; and he rested on the seventh day from all his work which he had made." On that seventh day, though, the dynamic forces of the earth were already in motion, nor have they ever rested since.

Most of the earth's surface is shrouded most of the time by great areas of white clouds. Much of this cloud cover occurs in great spiral whorls and even still pictures can make it obvious that the whorls are rotating. (The clouds rotate in one direction in the Northern Hemisphere and in the opposite direction in the Southern.)

Simple observations of cloud movements provide only one clue to what is going on in the atmosphere. However, they are sufficient to lead to the conclusion that the earth's atmosphere is dynamic.

The surface of the earth is mostly water—the oceans. Casual observations of the oceans do not readily reveal evidence of the dynamics of the seas. Storm waves reflect more the dynamics of the atmosphere than of the water itself. Although tides are evidence of dynamic action within the oceans, and although observing them at some places can be a dramatic experience, they have little effect on the oceans as masses of water. Closer observation of the oceans, however, reveals a system of circulation of the water that is spectacular in its magnitude and complexity, though less obvious and dramatic than the circulation in the atmosphere.

Casual observation of the solid earth reveals that it, too, is dynamic. Almost everybody knows about active volcanoes, earthquakes, the slow rise of some shorelines and subsidence of others, and the relentless flow of sediment-laden water to the sea. Systematic investigation has revealed that the solid earth has been dynamic for about four billion years.

If we had a time-lapse movie of North America with one frame taken every 100,000 years over the past four billion years (viewing it would take about 40 minutes), the continent would appear to be something alive —it would grow. The relations of land and sea would be constantly and rapidly changing. Shallow, epicontinental seas would be almost continuous near the eastern and western borders. At times these seas would spread across the interior of the continent, submerging half or more of

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the total area. At various times, lofty mountain ranges with active volcanoes would emerge from the long, narrow seaways that were near the continental margins.

It is likely that in the early part of the film North America would be joined to Europe as part of a single continent. During the last five minutes of the film the continent would appear to divide like an amoeba and North America would move away to its present position. Man would not appear on the earth until the last 10 frames of the film—just over half a second of the 40-minute show.

On this fantistically dynamic planet, what can be the meaning of the balance of nature? The dynamics of the atmosphere, of the oceans, and of the solid earth show no signs of reaching an equilibrium, a condition of no change. Nature does not obey laws. The so-called laws of nature are human constructs, designed to explain observed relationships and phenomena.

The prevailing characteristic of nature is change. Change may be repetitive or nonrepetitive, in one direction or reversible, perceptible or imperceptible, cataclysmic or gradual. Natural changes result from interaction of matter and energy. On the earth most of these interactions occur at and near the interfaces between two or more of the major regions of our environment—the atmosphere, the hydrosphere, lithosphere, and the biosphere. Any interaction may produce new forms of matter. Within any region of the environment, these new forms of matter may be considered as beneficent or polluting, benign or malignant, evolutionary or catastrophic, depending on one's point of view.

The earth may have started without atmosphere or oceans; certainly it started without life. Indications are that the early atmosphere was quite different in composition from the present one and that the oceans must have started as essentially fresh water compared to their present salty condition. When interactions of energy with the oceans and the atmosphere resulted in erosion of the lands, both air and water were changed—perhaps one could say they were polluted.

Roughly three billion years ago photosynthesis occurred in the oceans. At first this process may have been abiotic but soon it became biotic, and the algae appeared. A new kind of pollution occurred in the oceans. The biologic refuse left by the algae had an affinity for clay material eroded from the lands. The shales deposited in the seas ever since have been mostly gray or black. The pollution that makes shales black concentrates radioactive elements, thus compounding the pollution of the environment. Some dark gray to black shales are abundantly fossiliferous, so there must have been animals that could adapt to life in doubly polluted surroundings.

When animals appeared on the scene and populated the shallow seas in abundance, it must have appeared to thinking algae that the balance of nature was being disturbed.

Ultimately, both plants and animals invaded the lands. The first land animals were probably scorpions.

They were soon followed by amphibians and then by reptiles. Amphibians, restricted to life near the water, must have looked upon the land-roving reptiles as a serious threat to the balance of nature.

While the reptiles were having their day through the dominance of the dinosaurs, they must have been aware of the emerging primitive mammals scurrying around, in, and under the bushes. All of the major groups of animals were present to witness the demise of the dinosaurs. Whatever exterminated the dinosaurs, whether egg-sucking mammals or pollution of the environment, it did upset the balance of nature.

As the centuries passed, successive groups of mammals appeared and thrived only to be greatly reduced in number or exterminated by factors that upset the balance of nature as it was in their time. When, at long last, man stood on his hind feet and took to the ground and to thinking, it must have worried the anthropoids he left hanging in the trees.

The rise and fall of invertebrate groups, such as the trilobites, brachipods, ammonoids, and others is equally illuminating. The history of life—plant and animal—bears abundant evidence of the continuous imbalance of nature. It is humiliating to contemplate the possibility that man appeared because of the reversal of the earth's magnetic field that permitted harmful radiation from the sun to produce mutations in anthropoid genes. Harmful to whom or what? Can it be that man is an accident of an unbalanced nature rather than the goal of a balanced nature?

Human civilization began late in the last frame of our 40-minute movie, just as the shutter closed on the last click of the camera. During this microsecond of his own existence, man has been managed by his environment. He has explored and settled the wilderness, albeit not always wisely. His understanding of nature now permits a small minority of his number to win from nature the materials essential for life and some of the amenities of living. For all mankind, the time of reckoning has arrived.

The Western World is now in the throes of urbanization. We find our existing cities badly situated to meet modern needs. Most of our great and growing cities are on waterfronts—ocean shorelines or rivers. Many of these waterfronts are also political boundaries of one sort or another and this is troublesome. The commercial heart of the city is on the waterfront, and the immediate hinterland in many instances is less than ideal for the settlement of heavy populations. Both shorelines and streams are naturally in the lowest part of the landscape. These are places that naturally become dead air pockets on occasion. Dead air is easily polluted by noxious gases from urban life and living.

Many of our cities are on flood plains, areas so named because they are subject to periodic inundation. Everyone for hundreds of miles around must tithe through taxes to protect homes and commercial establishments that should never have been built where they are. It might be cheaper to buy the flood plains

and require the residents to move to higher ground.

Not all of our problems are in the cities. We are damming most of our streams with full knowledge that the natural fate of lakes and reservoirs is to fill with silt. It may take them a hundred years or so to fill up, but even this seems like short-range planning for long-range civilization.

We are paving a million acres a year for highways and an equal area for parking space. We are draining the swamps and straightening stream channels to speed runoff, only to discover that not enough water seeps into the ground to maintain the water table at an appropriate level.

We are decimating pests with pesticides, only to discover that elm trees are dying because we cannot control a pesky beetle. We are force-feeding our crops with fertilizer and finding that the runoff is loaded with nitrogen, to the delight of the algae in our lakes and streams. The algae, whose ancestors initiated pollution, may rightly feel that pollution has finally come full turn.

Whether our plight is real or imagined, our reactions are either emotional or arrogant. Our emotional response is that none of the living things over which we have dominion shall be harmed. The supposed balance of nature shall be maintained for all time as it is. This might be sheer folly or worse for a nature that has always been dynamic and unbalanced.

The arrogant response is that we must take control of and manage nature. Even Congress is now giving serious consideration to ways and means whereby we can manage our environment.

I suggest substituting a third, more rational response than either of the other two. This is to approach our environment problems in a spirit of cooperation. In the end we will solve more of our problems if we learn to cooperate with, to humor, our dynamic environment. If we continue to ignore or fight the dynamics of our environment, we can only lose what we have in the way of civilization.

To cooperate effectively with our environment will require gaining greater understanding of its dynamics through research. The basis for effective research and cooperation is broad public understanding of what we know about nature and of what we can objectively define as the problems we need to solve. This broad public understanding must become a central concern of programs for the general education of all our people.

By the term *general education,* I mean to include all those academic experiences that help students develop the ability and desire to live effectively in the natural, political, economic, and social systems comprising the human environment.

Appropriate courses and individual study should provide adequate opportunity for each student to develop an understanding of the following concepts:

1. The natural environment is dynamic. It is possible to understand aspects of the environment in terms of the interaction of matter and energy through time. Energy for the dynamics of the atmosphere, the oceans,

and life comes from the sun. Energy stored or created in the earth's interior provides the power for the dynamics of the solid earth.

2. Man as a biologic being is part of a dynamic ecological system embracing all living things.

3. Man as a rational being is capable of cooperating with and utilizing the dynamics of nature to produce an abundance of the necessities for life as well as of the amenities for living. But increases in human population have provided continuous crises in the effective adaption of man to his environment. Understanding of nature and of man can provide the critical capabilities to meet critical problems.

4. Man as a social being finds it necessary to devise systems of individual, social, economic, and political behavior. These, too, are dynamic and subject to change with time.

General education must supplement specialized or professional education in order to give the student the ability and desire to engage in a lifetime of self-directed learning after formal schooling is completed. It should prepare individuals to search for new knowledge about how to maintain effective cooperation between man and his environment and for new ways of applying that knowledge. The student should also be made ready to accept individual responsibility for the development of improved social, political, and economic systems to meet the changing needs of society.

Instructional Aid on Chromatography Available

"How to Use Chromatography as a Science Teaching Aid," by Frank M. Ganis, Chairman, Department of Biochemistry, School of Dentistry, University of Maryland, Baltimore, outlines five procedures to separate mixtures of chemical substances. Each method stresses a new aspect of chromatography, progressing from simple to more complex techniques.

The wide use of chromatography to detect substances in foods, drugs, as well as constituents of blood and other body functions, make teaching the processes especially relevant.

The five methods described by Dr. Ganis bypass the necessity for costly commercial chromatography equipment, utilizing readily available equipment that can be carried out in the classroom or the laboratory.

"How to Use Chromatography as a Science Teaching Aid" is available from NSTA for 35 cents. A discount of 10 per cent is applicable on requests for more than one copy to ten. With an order of ten or more copies of either publication, a 20 per cent discount applies. Payment should accompany orders for $2 or less.