Circular 31

ROOTS of HUMAN PROGRESS


EDWARD STEIDLE

SCHOOL OF MINERAL INDUSTRIES, STATE COLLEGE
PENNSYLVANIA
1948
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>Man and Nature</td>
<td>6</td>
</tr>
<tr>
<td>Nature</td>
<td>6</td>
</tr>
<tr>
<td>Evolution</td>
<td>10</td>
</tr>
<tr>
<td>Religion</td>
<td>13</td>
</tr>
<tr>
<td>Man and Man</td>
<td>15</td>
</tr>
<tr>
<td>Man</td>
<td>15</td>
</tr>
<tr>
<td>Egoism</td>
<td>18</td>
</tr>
<tr>
<td>Ethics</td>
<td>21</td>
</tr>
<tr>
<td>General Education</td>
<td>25</td>
</tr>
<tr>
<td>Man and Minerals</td>
<td>30</td>
</tr>
<tr>
<td>Minerals</td>
<td>30</td>
</tr>
<tr>
<td>Soils</td>
<td>35</td>
</tr>
<tr>
<td>Forecast</td>
<td>37</td>
</tr>
<tr>
<td>Conservation</td>
<td>42</td>
</tr>
<tr>
<td>Conclusions</td>
<td>47</td>
</tr>
</tbody>
</table>

## ILLUSTRATIONS

- Figure 1. Primitive workers in the mineral industries established the fundamentals of mining and metallurgy.
- Figure 2. Illustration from De Re Metallica showing how fire was employed to break rock.

## PREFACE

An old philosopher once said, "God grant me the serenity to accept those things I cannot change, the courage to change those which I can, and the wisdom to know the difference."

It is time to take stock of how the human race has progressed—whether the trend now points toward greater evils or finer things.

The United States tries to establish a pattern for the rest of the world to follow in seeking an equitable existence for man. But to pretend to anyone that our democracy is living democratically is sheer hypocrisy. We live lives of spendthrift practices and waste, not knowing or caring where the next year’s appropriations will come from. Too many demand freedom and security with little or no concern for national solvency. It is the keynote to “ride the gravy train,” while bankrupt, financially and morally, for all practical purposes. We pretend that our freedom and security can continue because some United States citizens are standing in Europe and in Asia, and because we are annually pouring out almost twenty billion dollars for security programs in one form or another. Furthermore, as long as police forces are necessary to guarantee domestic security, we cannot expect external security without the use of similar agencies. God forbid that we drift into a static society unable to retrieve the deeper qualities of life!

It is time that we stop fooling ourselves and put into effect a program of “real” conservation. By this it is not meant that we limit our concept to planting new forests, preserving wild life or preventing soil erosion, but rather taking stock of the expectancy of our resources, expand-
ing human resourcefulness and effecting careful utilization and replacing of, or producing substitutes for, material resources.

Aware that the mineral arts and sciences must play an active part in any program of conservation, it is timely to offer a series of three circulars: 31, "Roots of Human Progress"; 33, "A Philosophy for Conservation"; and 35, "Wanted: Mineral Industries Colleges." The first is designated to consider the part man has played in regard to utilization, or waste, of the resources at hand, the aspects of his influence on nature and on his fellow man, and how he has progressed and might further progress. The second presents a plan for world-wide, unified conservation of human and material resources. The third offers an effective, working program for training mineral scientists and technicians, men who are aware that all reactions taking place in nature occur according to the immutable laws of nature, men who might find a solution for the ills of the world according to the patterns of nature.

Edward Steidle, Dean
School of Mineral Industries

January 1, 1948.

INTRODUCTION

Man is born on Mother Earth without knowledge or skills. Soon he finds physical needs for food, clothing, shelter, exercise, and relaxation. His personal needs are self-expression, new experiences, and amusements, while his social needs have been classified as work, status, security, friendship, companionship, and love. He finds himself infinitesimal in comparison to the whole. Oftentimes when he feels smug, he is actually riding for a fall. And nothing is much worse than frustrated man.

Countries devastated by war desire to apply the techniques of forward-looking resource use which will most rapidly bring their ravaged farmlands, mines, and factories to full productivity. Highly industrialized countries, already shocked by experiencing a shortage of some of their basic resources, such as oil, coal, and steel, are concerned particularly over the rapidity with which they are consuming their irreplaceable materials. For the less fully developed countries, greatest interest lies in the utilization of modern methods which will enable them to bring into sustained use resources as yet untapped and to build up more productive and diversified economies.

But these are differences only of emphasis and degree. Preventable and costly waste, both of renewable and irreplaceable resources, is a world-wide phenomenon. No country, however favored, has yet succeeded in fully exploiting the possibilities which the scientific utilization of resources offers for a sustained advance in the standard of living.

As we reflect upon our past, we envision prehistoric man groping his way through a life limited by animal needs, his only instinct that of survival for himself and his immediate family. He was wholly dependent upon
nature and his environment for the satisfying of his requirements. As he became aware that he could exert an influence on his environment, his mental powers, as well as his physical skills, developed and expanded.

As he came to realize that he could accomplish more with the aid of others, humans and animals, his awareness of his neighbors—his moral sense—developed. And as he discovered a society in which each man contributed according to his most efficient, specialized skill, the need was established for a means of exchange by which man could secure his fundamental needs of food, shelter, and clothing as well as their various ramifications.

As in all pioneering, the going was rough at times. Reward seemed far distant, and the obstacles to progress were many. Some discouragement was unavoidable, and it was natural to think that the far side of the hill might be more attractive than the slope up which man laboriously toiled.

In the development of modern civilization significant contributions have been made by many diverse peoples and groups. The average citizen can readily identify the contributions made by the man with a plow—the farmer who tills the soil, deriving his living therefrom and providing the sustenance for his fellow men. The average citizen likewise can identify easily the contributions of the man with a machine—the operator of the mechanical contrivances that provide communication and transportation, as well as the clothing and shelter necessary to man and the luxuries that make our daily life more enjoyable. Today, as a result of increased education and visible accomplishments, the average citizen recognizes the contributions to our way of life that are being made at accelerated rates by the scientist and the engineer. Our recognition of spiritual, moral, and legal guidance is not unusual and the preacher, the teacher, the doctor, and the lawyer receive consideration. But the average citizen is usually unable to recognize directly the contributions made by the mineral industries—industries upon which all of our modern civilization is directly and vitally dependent. The position of the man with a rock—the earth scientist who studies and interprets the form of the earth and its composition; the mineral engineer who directs the extraction of useful rocks from the earth; and the mineral technologist who prepares desired products from the rock materials—must be accorded appropriate recognition.

Despite the progress that man has made over the past several hundreds of years—progress that has greatly accelerated in recent times—there is still a great threat that faces man with increasing intensity. For, despite our present means of communication and transportation, man has failed to come to an understanding with his fellow men, and wars have repeatedly laid waste nations and either killed millions of people or left them destitute. The causes of wars must be studied and then eliminated, human cussedness to the contrary. Man must learn to live with and to co-operate with his fellow men, regardless of differences of race, creed, color, or language. New ways must be found to rejuvenate humanity. The “have-not” nations must be made to realize that only through conservation and efficiency can they produce the type of world in which they would like to live, while the “have” nations must learn that cooperation with all nations is the cheapest and most satisfactory way of continuing to make progress. The peoples of the world must unite in common determination to eliminate war as an instrument of national policy. Then, when peace is really guaranteed to all, and when no defections from the cause of the common good are possible, man can look forward to an era of living in which the full benefits of modern science will be obtained.

In mineral industries we have at hand the means for
studying the geologic past, the technologic present. Ours is only one of the fields in which men must be developed to lead the way to the bright future we hope is in store for us.

MAN AND NATURE

*Nature*: Man is but one of the creatures which inhabit the earth, a dust speck in the universe. Thinking man has been concerned with his place and purpose in the universe since the earliest Egyptian and Chinese philosophers. Ancient creeds, as well as modern religions and philosophies of life, were concerned with the same problem. While such considerations and concepts have been valuable, theoretical philosophizing and dogmatic concepts are inadequate for a satisfactory solution of world problems of today. The concepts of man and life and their ultimate purpose should be sought in the relations of intelligent man to man and their relationship to the physical world.

The quintessence of nature’s accomplishment—man—is also the greatest disturber of nature and the greatest enemy of his own kind. While his spirit and mind defy and overcome natural limitations, his physical self is controlled by the same basic biochemical laws that govern any other form of living matter. This paradoxical duality of human voluntary and involuntary relations to nature is the source of the perpetual conflict between mind and matter. Therefore, the higher the spiritual evolution and perfection of the individual’s mind, the greater and deeper the conflicting elements in their expression; and conversely, the simpler the mind or the mental and spiritual heritage, the less is the individual concerned with the conflicting elements.

Nature is cruel—nature is neither good nor bad. It is just indifferent and impersonal to man just as it would be to any inanimate object. Man puts into nature the meanings and colors he sees and feels or wants to see.

The power of nature seemed absolute to primitive people, and the awful inevitability of fate appeared to be far beyond the mere power of mortals. Primitive man, having accepted his fate, was happy in his way and did not attempt to change his destiny beyond the narrow limits imposed by the bleak and forbidding environment in which he lived. He worshiped nature and attempted to placate the evil spirits by appropriate sacrifices, rather than by challenging their powers. However, since man possesses a brain that is capable of utilizing and directing natural resources and forces sufficiently to change his environment, he is consciously modifying nature.

It must be realized that dynamic power is abundantly present in nature and that, in order to modify nature’s equilibrium and even to reverse the course of apparently inexorable natural processes, it is necessary to apply relatively small amounts of directed energy. What is important is that these be applied to the proper place and at the proper time. As Archimedes said, “Give me a lever and I shall lift the world.” There are many levers in nature, and adequate pressure upon the smallest one lifts man to a place where he comes into possession of a bigger lever, and so on.

When our ancestors domesticated sheep and discovered that corn grows from seed and can be planted and harvested, they became largely independent of the feast-and-famine economy (mostly famine) under which they had lived for untold generations. When they invented the wheel and the sail, and discovered how to burn coal and oil, and smelt metals from ores, they possessed and applied power in amounts sufficiently large to disturb nature’s equilibrium.

This process of overcoming the influence of natural environment has been going on for thousands of years.
The process has accelerated at such a rate during the past hundred years that, at the present time, humanity as a whole seems to be capable of developing enough technological improvements in machines and devices to shape a good portion of the universe according to its own mental pattern. Will this pattern be one of continued development or one of destruction?

Man now prognosticates his future as a sort of superman, impregnable against all foes, animal or bacterial, maybe with a defense against death itself, with a government and economy established which will be just and equitable to all men. All this because he has harnessed the atom. But wait! Nature still imposes her controls.

At present we are chiefly dependent upon the use of uranium for atomic power. The known sources of uranium-bearing ores will furnish enough uranium to provide atomic energy for only a limited time—disregarding the vast expense involved in any exploitation. Again we find ourselves limited by nature in the one essential to life we cannot disregard—water. Our bright dreams of exploring the secrets of the universe are suddenly dimmed by one human need.

A recent editorial depicted the West facing diminishing water tables with Southern California, Arizona, and other regions gradually declining into the status of the Great American Desert; lowering water tables in New England, acute shortage facing New York City and its neighboring counties; mankind forgetting in time its ideological quarrels, substituting for them bloody wars for possession of the Amazon, or the Mississippi, or the Volga; the human race dropping the use of nuclear fission as a means of furthering purely nationalistic ideas in favor of a plan to make atomic energy the means of saving the globe, putting tiny atomic reactors to work distilling sea water.

Man has established himself throughout all the places of the earth, drawing on all sources of energy and sustenance—gouging out minerals, draining oil and water sources, leaching the bounteous products of the soil—until he is now faced with waning supplies while his needs continue to increase. But he is becoming aware that nature's equilibrium cannot be upset—he cannot eradicate one pest without another's increasing and possibly becoming a worse menace. He has found he must replace the forests he has destroyed, replenish the soils he has exhausted, and he is facing the problem of efficient utilization of the minerals left for him, of providing substitutes, for he can now foresee the end of supply.

Estimates of the world reserves of selected metals and minerals in terms of supply, based on the various rates of per capita consumption, are: iron ore, actual 200 years—potential 625; manganese ore 250; chromite 47; tungsten 125; copper 45; lead 33; zinc 39; tin 38; bauxite (aluminum) 200; petroleum, proved and indicated 22—ultimate 160; and coal, the world's major asset, 2200 years. The estimate for coal is highly controversial, not being estimated in terms of quality, minable coal. Assuming that the world per capita consumption was the same as the United States, the reserves would be: iron ore, actual 25 years—potential 74; manganese ore 50; chromite 8; tungsten 34; copper 5; lead 4; zinc 6; tin 6; bauxite 31; petroleum, proved and indicated 2.5—ultimate 18; and coal 340 years. It is evident that discovery and present methods of exploitation will not suffice for future demands and that we must, therefore, develop new skills and techniques, evolve new materials to utilize more efficiently and augment those we have known in the past.

There are many factors affecting man and his history on earth. It is well to study man's past, and the earth's past, in order to better predict and plan the future.
Evolution: Fossils imbedded in the sedimentary rock layers formed by ancient seas and rivers bear witness to the marvelous history of creation of the earth's life, its ever-changing kaleidoscope of plants and animals rooted in the obscurity of a billion years ago, and giving rise to man in only the last thousandth of its long record.

To the geologist, the march of these past creatures affords both an immensely valuable tool in his investigations of the structure and mineral wealth of the earth's crust, and a means of interpretation of the earth and its inhabitants. It provides a major key to many subsurface structures drilled for petroleum; furnishes major clues to shifting geographic scenes that spread marine sands, clay, and lime layers where now are mountains, stripped away mountains where now are plains and even seas; reveals time relations of rocks of every continent; and reconstructs for modern man the living creatures of the past in a wealth of information of form, origin, and habits.

The ever-continued creation of new life-forms apparently resulted from evolutionary modification of descendant as compared to ancestor, the changes progressing slowly in time as humans know it, rapidly in the thousands of million years of earth history. Changing architectures of body provided differing solutions to problems of living, growing, surviving, reproducing.

The development of living organisms has been intricately divergent. Differing body designs, variably successful for life's needs, have developed side by side, somewhat as man in his search to conquer space has invented oxcarts, automobiles, express trains, all wheeled to roll over land surfaces; rowboats and Cunard liners to venture on the seas; airplanes, jet planes, and rockets to reach the skies. Appreciation of a luxurious streamliner does not detract from the wonder of a finely proportioned ship; our love of womanly beauty need not blind us to the marvels and ingenious achievements of the diverse organisms that grow stately forests, produce the graceful birds and butterflies of the air, or populate the submarine wonders of the coral reef.

Unlike man's inventions, living creatures are endowed with the power of self-reproduction. New generations arise through growth from the "germ plasm" of seed and pollen, egg and sperm. Germ plasm with its capacity to continue life preserves a potential immortality, and is set aside early in the embryological life of the individual; other plasm specializes to grow the body or soma of the creature, loses its reproductive capacity, and automatically destined itself for death. In a sense, the soma generations of man or beast are simply temporary abodes for the long-living, continuing strand of germ plasm from which they are developed. In its own complex reproduction, germ plasm is not perfectly stable. Its changes immediately are reflected by modifications of the somas it produces. New creations usually modify in small ways their forerunning ancestors, though rarely there are basic discoveries that by long trial and error give rise to new categories of life. Just as new concepts of human rights and dignity had far-reaching results in the organization of American society, so self-invention of an internal, growing skeleton was a major step in development of the vertebrated creatures that eventually gave birth to man himself. Understanding of the extraordinary qualities of all living organisms enhances and does not reduce mankind's regard for the living communities of which we are a part.

A knowledge of paleontology and geology does aid appreciation of man's relationship to the world around him. The effects are great and small, showing up in quite extraordinary fashion. In minor detail, street directions in State College are resultants of geological conditions and events whose roots spread hundreds of mil-
lions of years into the past. The streets parallel or run perpendicular to trends of our valleys and adjoining mountains; these follow the strike of the rock strata, developed during Appalachian folding of 200 million years ago; the fold trends in turn were controlled by features of earth-architecture inherited from a far more distant past. More importantly the early German settlers of Pennsylvania and Virginia knew that fertile soils weather from limestone rocks; they sought the valleys where geological folds bring to ground surface the great limestone layers of the region, and shunned other barren, shale-floored lands. The whole course of the Battle of Gettysburg, where reportedly more men died in one hour of Pickett’s Charge than were lost by American forces in the first three days of the Battle of Normandy, was profoundly affected by protection afforded the Union army by the boulder-strewn ridge of ancient volcanic trap rocks that cooled and solidified during Triassic time about 175 million years ago. The forty-niners scrambled for gold concentrated by other rocks that cooled from their molten stage about 150 million years in the geologic past. A major object of Hitler’s Norway campaign was control of the Swedish iron ores.

Thus, the effects of these inorganic results of geologic history are tremendous and far-reaching. Nonetheless, they often are overshadowed by ingenuities of the men who discover ways to use them, and who owe their characters to the evolution by which they were themselves created.

But all life processes are irreversible—birth, death, evolution. It is suggested that science will finally attain the understanding of “the life principle” to explain the reactions in living matter. Even if natural sciences discover the origin of life and the laws governing life, the question “why” can never be answered by scientists—therefore, religion takes over. 

Religion: Religion involves an active belief in a power greater than man, a God who directs the ways of the universe and of individuals in it. Being a belief, the nature and expression of religion varies with the individual’s temperament and background. Its worth is judged by the degree to which it beneficially affects other individuals and society as a whole. Just as training is essential to the making of a successful scientist or doctor, it is necessary if the individual wishes to do the greatest possible good for his and future generations. Thus, for example, for many studying the art of doing good, Christianity is the course, Christ is the professor, and the Bible is the text.

Religion is regarded as an art and therefore, presumably, not a science. But science without a philosophy of religion is poor, narrow, and may be bent for evil and destruction. Religion is like a great symphony or painting. It can be interpreted but not explained by a logical sequence of well-established facts such as goes into the making of a scientific law. For this reason, science and religion are set apart from, and even believed to conflict with, each other. In the minds of many, as science grows in stature and explains more of nature’s laws, the case for the belief in God the Creator loses ground. Judging from past achievement it is possible that scientists will some day “explain” the origin of life; show, perhaps, that the “divine spark” was ignited by a sudden unique but scientifically explicable eccentricity in the vibration characteristics of a few electrons. If so, did this happen by chance? Does the universe exist by chance? Is it by accident that man, as opposed to other animals, has sufficient intellect to explain and partially control nature? Man is closer to “God” when close to nature; then his mind may tend to abstract. When living in large communities his mind is more material and more shallow and trivial, as he usually is. One has to
have faith in something—perhaps children in parents, old people in God—or fall to a negative level.

There is nothing in the mineral arts and sciences that belies the existence of a Creator. The wonders of nature daily being discovered by man are not new. They have been hidden along with many others that man has not yet discovered, or has seen but does not comprehend. In science we are not creating new Truths; these exist, and man is simply elevating himself to a position of sufficient intelligence to appreciate them. Who can say that he will ever increase his intellect sufficiently to understand far greater laws of the universe or to get even an inkling of the reason “Why?” The same vast concepts that Einstein reveals surrounded the Neanderthal Man but meant nothing to him (and, for that matter, to most of us). Because man has progressed, in a very short increment of geologic time, from the Neanderthal to Einstein, are we to assume that he now approaches a complete knowledge of the workings of, and the reasons for, the universe? A universe we do not understand, and possibly never will, in itself implies a Creator we will never comprehend. Does this mean he does not exist?

Prayer is scoffed at because it is illogical and does not rely on well-founded scientific principles, but what are scientific principles of today as compared with those of tomorrow; and those of tomorrow, as compared with those that actually control the universe? May not God’s laws be great enough to control the movements of individuals as well as the movements of the stars in the heavens and the electrons in their orbits? May not His response to a prayer be as much a part of His “scientific method” as is the derivation of a mathematical equation a part of ours?

Man’s science does not dispute the existence of God. It is at such a primitive stage in relation to the true science of the universe that the arguments it can ad-

vance are untenable. Rather, in revealing the amazing order of the universe, science suggests that there are greater laws man cannot define, created and maintained by a Power he cannot comprehend.

Science and God are identical if the scientist creates with emotion or a philosophy of religion which is invariably personified in his desire to give, to create for good and beauty, if not perfection. This creation within a high altruistic spirit of the Great Masters will bring the scientist closer to God. This is his religious elation.

It is a rare privilege that through the eyes of the Great Masters, man can know the Will of this Power working in his own heart. With Religion, his science can be directed to ends beneficial to all his kind. But man must not be afraid of responsibility, nor try to avoid it. And he must not seek refuge in forgetfulness and limbo.

**MAN AND MAN**

*Man:* A purely detached consideration of nature and the place of man in it may easily result in somewhat pessimistic conclusions as to man and his destiny. However, when we come to the evaluation of man’s role in the development of natural resources and his achievements in this field, a more optimistic tone may be justified. Hence the possible contradictions between Man and Nature, Perfection, and the present chapter are more apparent than real. After all, progress must have a foundation of optimism, and we cannot challenge either the faculty or the students to better work and to a progressive and constructive outlook without an underlying tone of optimism and basic faith in the future.

Geology is the basic science of Mother Earth; the science of the natural forces that have produced and modified the structure of our globe; the science of minerals and rocks; of landscapes and soils; of water supply
and mineral resources, including mineral fuels; and of the history of life, both plant and animal, as revealed by fossils in rocks.

It is difficult to reduce man and his historical significance to their proper relationship with regard to the earth and its history. Processes of rock formation have continued for at least two billion years; man's activities have been in evidence only a few thousand years. As a means of comparison, if the height of the Empire State building were to represent geologic time, the thickness of a nickel placed on the tower would just about represent the time of human existence. A postage stamp placed on the nickel would represent all human history. Little change can be perceived in the contour of the earth over a period of three score and ten years, in spite of the fact that 36 billion tons of silt-in-suspension and mineral matter-in-solution are carried into the Gulf of Mexico alone during that time. Greater strides have been made in man's interpretation and understanding of the earth and the benefits to be derived by applying his ingenuity and inventiveness to the inanimate objects at hand in the last 70 years than in all former recorded history.

Geology teaches us that life first appeared in water more than 500,000,000 years ago; that man appeared on the earth a million years ago; modern man, about 30,000 years ago, a very short time geologically. Man can be considered as a distinct species, but he is of the same species, whether pygmy or Caucasian. And geology tells us that various animal and plant species have been doomed to eventual extinction through failure to adapt themselves to changing environmental conditions. And what of man? He, too, is an animal, distinctive only because he has been endowed with "gray matter." Is he, too, doomed to extinction because he cannot rise above the animal instinct of preying upon his own kind?

But none of the extinct forms had possessed "gray matter," a property which seems to be restricted to Homo sapiens. Brains and their product, "technical know-how," can be defined as the ability to successfully overcome unfavorable natural conditions through the application of directed power or energy. No animal predecessor was capable of doing this. Hence, the fate of Homo sapiens cannot be predicted from the records of historical geology and, to a very large extent, his future destiny is in his own hands. But humans must have more faith in accepted and tested moral codes than in police force in order not to eat one another.

Human resources should be the greatest wealth of any country. Numerically they have become so great in some countries as to be a serious burden. Man, struggling with adverse conditions of nature's physical environments, is endowed with intelligence, perseverance, and patience by which means he vanquishes the obstinate natural forces to make them serve his purposes. The Icelanders and the Finns prosper in the hostile and bleak northern countries, while other peoples are making progress in the enervating tropical areas of the world, developing flourishing and highly cultured communities under naturally adverse conditions.

On the other hand, rich lands—inhabited by primitive peoples—progress at a much slower rate or possibly not at all. Thus, we have old human communities in Africa, living in highly primitive conditions on a fertile and rich land; certain Mediterranean countries in Europe are notorious for their backwardness despite rich coastal lands and an old civilization; finally, some South American nations or tribes with vast resources of soil and sub-soil still have an incipient civilization. Culture remains static, much as it was centuries ago. Modern concepts of progress have not penetrated to these areas and they remain unimproved islands with no evidence of desired
improvement. There has been only limited application of human resources.

These examples illustrate our thesis and serve to show that a country is only as rich as its people are resourceful and capable of creative activity. It has been ably stated by Ruskin, the famous English critic, who began his illustrious essay, *Unto This Last*, with the words, "There is no wealth but life."

Man is generally master of his destiny, as are groups of people, or nations. Endless resources are in the hands of man if he finds the way to capture and control them. But he must first learn to control himself. Through research he will find the way to harness the sources of energy, food, and raw materials that are ignored today. And through a true awareness of the needs of his fellow man, he will employ these resources for the benefit of all.

Research and more research, co-operation and more co-operation, in all fields of endeavor, are needed to create the man of the future; not the fatalistic man ready to accept whatever nature generously or niggardly gives him, but the man who can control nature and his own fate. A strong sense of duty and fair play must direct these efforts toward the common good. A world thus strengthened by men of character will no longer find its several nations dependent upon their own stores of commodities. This is the one way to banish fear and want from the face of the earth—by setting aside material and physical improvement and concentrating on improving the moral relationship of man to man, of nation to nation, of race to race.

---

_Egoism:_ It is highly discomfiting for those who live in the present world to be squeezed day by day by the ferocious dog fight that goes on among the different competitive egoisms. Why must we live with the unethical doctrine that individual self-interest is the valid end of all action? Why is it that ethics comes out of the unscientific east and techniques out of the west? When will a westerner of sufficient culture and moral standards, filled with knowledge and faith, stand up courageously and proclaim with strong arguments the need for cooperation among men for the good of humanity?

Egoism, the habit of regarding self as the center of everything, dominates the world possibly more than ever before. If it continues to gain ground, the future years, perhaps the next year, will bring another war that will fill the human race with primitive terror. Einstein has said, "I don't know what kind of weapons will be used in the third World War, assuming there will be a third World War, but I can tell you what the fourth World War will be fought with—stone clubs." If egoism, inventiveness, and culture continue to grow in parallel lines, man will march with accelerated pace to suicide.

Nature provided man with exceptional qualities, a brain for thinking and language to impart the results of his thinking. These qualities make man practically master of the world; he has been able to expand his dominion over his environment. Consequently, he should act more decisively and more promptly in breaking away from the strong traces of beastliness that he has inherited. But because human beings with intellects are relatively new on the earth, geologically, it is too early for man to understand completely all the purely material, bad aspects involved in his civilization. And Cowper once said, "When men of judgment creep and feel their way, the positive pronounce without dismay."

History demonstrates that the man with a gun is often the unwilling effect of the man with a pen. Mussolini was an editor of a newspaper before his climb to power, and he used his paper to start the Fascist movement. Hitler wrote *Mein Kampf* which was the start and the
bible of the Nazi movement long before his men had guns. Lenin was the editor of *Iskra*—a revolutionary paper printed in Switzerland and smuggled into Tsarist Russia; later he wrote *What Is To Be Done* which laid out the plan for the red revolution. Stalin was an editorial assistant to Lenin after writing some propaganda in Georgia that came to Lenin’s attention. Karl Marx wrote *Das Kapital* which started the whole communist train of thought. And even in Japan the whole plan for a greater East Asia expansion was propounded years before 1932 by Tanaka in his written memorial to the Emperor. After men with pens inflame their fellow men and set the stage for conflict, then guns are forced into the hands of the common man with the threat that he shoot the enemy or else be shot himself.

In general, man has not yet reached the point where he uses his special qualities for the benefit of the human race. Exceptional men, some of them real supermen whose religious spirit and humility have made them saints, have tried to make us understand that co-operation is necessary for the benefit of humanity. Christ made profound progress toward that ideal and made possible enormous social betterment. Eventually the social spirit like that found in the Christian religion will dominate the world. If we have not reached that point, it is because those who claim to propagate Christ’s ideal have not been big enough for the task, because man has not been able to rid himself of ambition, hate, covetousness, avarice, fear—of all those qualities which make him less than a man.

The superior man, the man of culture, should devote some energy, sometime, to spreading the social spirit of Christianity. He must work with all religious sects, reach an attainment of rational understanding, and strive intensively toward frank and loyal co-operation among men with no prejudices as to race or religion. Surely all the religions of the world are alike in their basic structure, because they all move toward the same objective—perfection of man’s relation to man and the subsequent benefit to humanity.

If we purge man of all the prejudices inherent in his lowly origin, there will result that high spirit known as the Divine. It is found in Mohammed, in Buddha, in Confucius, in Christ. Once man abandons his excessive egotistical ambition and the fears engendered by his excessive competitive spirit, nothing will stop him from understanding his fellow man and establishing real co-operation.

But this ideal is difficult to attain. Too many of us shout pious platitudes and noble resolutions but do not convert them into action. Oftentimes we forget that we do the shouting to young heads on inexperienced shoulders. Those who should be leaders adopt an agnostic attitude toward every important social issue, support all sides without committing themselves to any of them. They are inclined to delay action until all facts are in, though they know that all the facts will never come in. Consequently, they withhold their judgment and, after passing the age of maximum usefulness, see their powers of action and social sympathies fade and sink into oblivion. They are much like a geologic theorist engaged in the studies of ore genesis. By the time he has a working hypothesis as to how the ore was formed, the mine is exhausted.

**Ethics:** Ethics may be either a sense of duty, a moral obligation or the ideals of character conforming to preferred standards of conduct. Perhaps it might be defined as a code of conduct superior to that enforced by legal means and one which is followed voluntarily in the interest of good citizenship. Therefore, it is important
that, as part of their education, our students acquire a knowledge and appreciation of those standards of behavior which are rated highly in their profession. Good education consists, in large part, in the formation of good habits of body, mind, and morals.

It must be remembered that success in any profession cannot be measured by the mastery of technical information alone. It implies also an ability on the part of the professional man to project himself into the perspective of human society at large. It entails a willingness on his part to concede that he is a human being even before he is a specialist, and that as a member of society he will earnestly desire the greatest good for the greatest number. It is no longer possible to adhere to the view that the scientist should work only in his laboratory, devoid of a political or social philosophy. The well-trained technologist attains professional status only when he recognizes his obligations toward his fellow man and becomes aware of the trusts that are imposed upon him. Many hundreds of years ago Aristotle observed, “Man is by nature a social animal and human morality is social to the core.”

The professional man may lose the faith of his fellow man because of the limitations of his knowledge or the shortcomings of his skills. More frequently he will lose it because he violates its obligations and its trusts. The physician who calls upon fellow practitioners for a consultation in a time of grave need is seldom to be criticized for his caution. Failing to meet the need for consultation at such a moment, in overweening pride, may place his moral conduct on a lower plane.

Society has two protections against the infraction of professional obligations: (1) laws; and (2) professional ethics. Law is a code of conduct in the establishment of which society at large has participated. Professional ethics represents a code originated by the members of a profession to memorialize the standards of conduct desired of them for the good of all mankind and for the good of the reputation and social standing of the profession and its individual members. Each member of society is concerned with law, but the professional man is also concerned with a code of ethics because he knows that strict compliance with these standards will obtain for him the respect of the fellow members of his profession and will facilitate the recognition, by both public and profession, which this respect engenders.

Ethics, it thus becomes clear, concerns itself with the benefits of society as a whole by giving the professional man a sense of duty and of moral obligation. A code of ethics is not concerned with monetary rewards but rather with a humanitarian goal whereby society obtains the greatest benefit. These codes become even more important agencies for social control as modern life becomes more complex. Under those conditions many individuals are unable to judge whether a member of any profession has performed his services with due regard to the interests of his clients. In all but the crassest and most obvious defaults in service standards, the work of the physician must be judged by physicians and that of the lawyer, by lawyers, and so with each of the professions. The higher the skill, the greater the need for organized group effort toward maintaining a fine sense of obligations, not primarily to others in the same profession, but chiefly to the general well-being of all.

We must emphasize the need for growing standards of professional conduct at a time when the fabric of society is breaking apart under the stress of our complex life. The older interpretation of a simple political structure is giving way to the modern conception of the corporative state, a society in which the constituent units are not parties or political subdivisions, but func-
tional groups, such as trade associations, labor unions, consumers’ co-operatives, professional guilds, agricultural groups, and the like. While many of these changes have created modern day problems, it is believed that in professional bodies, the idea of collective superiority has been vindicated. As a group, the professional body tends to act on a higher plane of idealism and devotion to the common good than do individuals. The future of society appears then to depend more upon the vitality of such functional groups. A suitable objective would thus be to extend professional ethics and ideals to the wider areas of industrial and public life.

Can a single code of ethics suitable to every profession and every business be formulated? On first sight the unifying aspects of public service would seem to make such an objective easy of attainment. But ethics cannot be summed up into a series of inviolate rules or commandments which can be applied everywhere and always without regard to circumstances, thought of consequence, or comprehension of the end to be attained. What is universal is the good in view, and ethical rules are but generally approved ways of preserving it. When the standard rules clash with one another the only solution is to seek guidance toward established ideals. In business dealings the practice of reciprocity should be based on integrity and fair play.

Regardless of the inability to formulate a universal code of ethics the mineral industries can never use this excuse for living without such a code, because minerals are irreplaceable, found where nature places them, and in concentrations prescribed by nature. On analysis it will be found that all adequate professional codes attempt to provide guides to conduct in the professional man’s relations with the public at large, with fellow workers in his profession, and with his employer. As Taeusch expresses it, the primary aspect for the professional man to consider is the effect on the welfare of the public. Next in importance, he must consider the effect upon the other members of the profession and the profession as a whole. Finally he must give the matter of loyalty to his employer adequate consideration.

General Education: Most men in their quest for comfort and security have paid little attention to the higher values of mind and spirit. The inclination has always been to measure human progress in terms of material developments which are at best of a fugitive nature. The neglect of the mental and moral aspects has an important, if not the major, bearing on present world turmoil. This far-reaching upheaval not only concerns Europe and Asia, but the Western Hemisphere, including the United States. In view of the gravity of the situation, it would be well to examine some of our basic philosophies of higher education with the hope of placing them in their proper perspective.

While humanity as a whole may be headed for the stars, technologically at least, man as a single individual is still very much at the mercy of natural laws and of his own passions, and his personal fate cannot be weighed in the same balance as that of collective humanity. This difference between the inevitable destiny of one single person and the possible history of the entire race has produced a conflict which, at the present time, is deeper than ever and must be solved if humanity is to survive.

Confusion is rampant in education. Recently, professional educators turned on the heat for more “general education,” but they fail as a group to face the truth. Self-expression cannot take the place of self-discipline. Who goes through life on self-expression? What is sorely needed in human relations the world over, is more self-discipline, mental discipline. The hit-or-miss type of
elective-choice guidance offered at many colleges provides a fitting basis for the hit-or-miss quality of the majority of the graduates whose degrees imply, but no longer guarantee, men trained to take their places in a highly competitive society.

The greatest lack in our college students is an adequate knowledge of mathematics, chemistry, physics and languages. In the highly technical world of today, where any discussion involves the use of statistics and statistical interpretations, and terms such as atoms, neutrons, mesons, quanta, amines, relativity, and magnetic force, it is imperative that everyone at least be acquainted with such terms. Our youths are constantly bewailing their mathematics and Latin requirements and are trying to have basic courses dropped from their curricula, yet their use is ever present in day-to-day activities and thinking. It is not only indispensable that science and language courses be included—they should be increased.

We need to plan comprehensive, general academic education of not only lower-divisional and upper-divisional requirements, but sequentially arranged requirements. First the foundation should be laid in mathematics, chemistry, physics, and languages, then geology, botany, zoology, biology, geography, to be followed by humanistic-social subjects. This general plan should be followed in all branches of education—be they pre-law, pre-medicine, science or liberal arts. There are a few colleges which offer a carefully scheduled 4-year counseling program, with each credit hour selected to provide the most beneficial training for the objective of the specific student. This practice should be more widely advocated, providing education for the sake of education and not for the easy attainment of a degree.

Two years ago the undergraduate curricula in the School of Mineral Industries of The Pennsylvania State College were overhauled completely to meet the changing requirements of industry and modern civilization. Further changes are needed now to arouse student consciousness of human problems and to provide a background of information that will help them take leadership in their solution.

Training in Mineral Industries curricula embraces three major types of work: (1) fundamentals in English, mathematics, and the natural sciences; (2) basic engineering courses; (3) subjects of the selected profession; and (4) electives in the fields of the humanities, management, and technologies.

We have tried for at least ten years to discover a way to make the available humanistic-social courses more effective in mineral industries education. The object is greater social consciousness. The existing divisions of subject matter from which humanistic-social work may be chosen are:

- Languages
- Geology, geography
- History, economics, psychology, and sociology
- Political science and government
- Comparative religion
- Fine arts

Recommending this array of electives is equivalent to prescribing a superficial paint job on a car when a basic engine overhaul is needed. The attempt is far too shallow in view of the importance of the problem.

Present-day conventional, humanistic-social courses offer little hope. These usually are not correlated; in fact, respective departments are fenced in. Human and intellectual aptitudes have not been balanced. The origin, progress, and promotion of civilization are ill-understood and misconceived. The attempt to gain by adding specialized, humanistic-social courses here and there, even under the best of conditions, is wasted effort.
I advance the idea that we must make a new approach to arouse the interest of the general student in the bases for the progress of mankind. We must return to fundamentals, discarding for this purpose the highly departmentalized and specialized type of course, and turn to closely integrated "beacon" courses that will highlight man's basic needs, his problems, and his resources. I would like to call the courses Roots of Human Progress, Parts I and II. Part I, first semester, would include subject matter designated Man and Nature and Man and Man; Part II, second semester, subject matter designated Man and Minerals and Man and Conservation.

The series would cut across all natural science and humanistic-social subject matter fields, irrespectively; in turn, it would lead students to further use of electives in fields they find interesting. The series would be made "tough," predisposing a mathematical and scientific background and mental discipline, and calling for written and oral reports, to give practice in self-expression as well.

Undeniably, this would call for unusually skilled teachers, but where there is a will there is a way, and such teachers could be provided.

Man as an individual is inseparable from his fellow man, and his own problems and welfare are integrated with the problems and welfare of the rest of the world. Man is also an inseparable part of nature. Only in the combined study of his relationship to his fellow man and his relationship to nature will he find himself.

It is the duty of all of our institutions to prepare young people for the two-fold task of assimilation with nature and other men. The School of Mineral Industries is playing its part by training skilled scientists and technologists to discover and utilize nature's mineral resources, to improve man's material lot, and to develop responsible citizens ready to contribute constructively to humanity's spiritual welfare.

A philosophy of helping others to help themselves—this is education and may be applied on an individual, a community, or a national or international scale. It is not charity, which precludes dignity, self-respect, a feeling of constructive contribution to the welfare of permanent peace.

The Great Masters always appealed through the heart in the greatest of simplicity. Man of today must understand and practice the teachings of the Masters on an intellectual level.

In this age of technologies, education does not make for democracy and the progress of human relations, unless educated men understand the social implications of new discoveries. Technologies develop amorally, but there is no need to clash with the morals of a community. Social implications must be governed by progress in the ethics of human relations. Scientists and engineers can lead the way because they are trained to be little affected by preconceived ideas. Scientists and engineers, working with others, should tackle the job at once to convince the world that co-operation among men is essential to all. Once momentum is established in solving cultural, social, and economic problems, there will spring forth new hope for conquering the specters of war and misery, and a new generation will arise to lift the level of human life and of moral standards to heights now difficult to foresee. May such an epoch come speedily!
MAN AND MINERALS

Minerals: When man first picked up an appropriately shaped stone and fastened it to a stick of wood to create a primitive axe or hammer he started down the long road of mineral dependency that has continued until today (Fig. 1). Though he did not realize it, that man and his stone axe created an extremely simple form of mineral economy. The struggle against extinction from that day has been fought with minerals.

In addition to providing himself with a means to fight for survival, he also exhibited an increase in intelligence. As his curiosity was stimulated, his ability increased to provide himself with better mineral and metal weapons and tools. Today, when we examine the artifacts of past civilizations, we measure the degree of development that had been attained by the variety of metals and minerals possessed and how they were used. The metals employed are so characteristic of the level of intelligence that we have named the various stages of human progress by the metals that were most commonly utilized. Thus, man went through the Stone Age, the Bronze Age, the Iron Age and now has reached the Steel Age.

The first period of mineral development, the Stone Age, began during late Pliocene time. In this first mineral age, prehistoric man began to shape stones by chipping off small pieces until the stone assumed the crude form he wanted. As his intelligence increased, he progressed to finer workmanship and turned out finished spear heads and barbed arrows. Throughout this very early period the only raw materials were flint, bone and wood. In later stages of development, the art of polishing and grinding was discovered and man was able to use other rocks besides flint. Progress was slow but constant and while still in the Stone Age man initiated ceramic technology by making crude forms of pottery and also began to use stone as a building material in constructing burial places, temples and monuments. Even international trade began in prehistoric Stone Age times. The various tribes in their wandering quest for food and suitable stone were bound to encounter other tribes and a system of bartering developed from these chance meetings. Flint, amber, and salt were most frequently used in that early trading.

It was virtually inevitable that sooner or later man in his search for flint and other stones to fashion into crude implements would discover one of the native metals. Gold with its yellow glint and occurrence in placers would seem most likely to have been the first metal for primitive man to discover. However, though he could hammer gold into whatever form he wanted, it proved much too soft for anything other than ornamentation. Available evidence seems to indicate that the first metal man put to practical use was copper, which also occurs in the native form, has a yellowish red color and is sufficiently malleable to hammer into desired shape. The use of copper for weapons and utensils marks the beginning of the metal ages at about 4500 B.C. Two other native metals were also discovered and used around this time, silver and rare meteoric iron. The exceptional qualities of iron were recognized even at that early date and meteoric iron was prized highly.

The next vital step in metal progress was the discovery of extractive metallurgy. The knowledge that metal could be taken from certain rocks by the proper use of carbon and heat must have been disclosed accidentally. The most likely place for that chance discovery was the campfire where there would be the necessary carbon, heat and metal-bearing rock. From then on it was only a matter of time until man began to reproduce and improve these conditions so that he intentionally could produce metals. The oldest smelted copper relics that
Figure 1. Primitive workers in the mineral industries established the fundamentals of mining and metallurgy.
The mineral industries have the oldest technical literature known to man. Pirotechnia by Vannoccio Birin- guccio was published in Italian in 1540, De Ortu & Causis Subterraneorum by Agricola, in Latin in 1546, and De Re Metallica by Agricola, in Latin in 1556.

Figure 2. Illustration from De Re Metallica showing how fire was employed to break rock.
have been found date back to between 2500 and 2000 B.C. The next advancement of technology was the production of alloys by the primitive metallurgist when he mixed various ore materials together. In this manner bronze and brass were discovered and used long before tin and zinc had been extracted from their ores. The first intentional smelting of bronze was about 1500 B.C. and iron was produced as early as 1200 B.C. And so man increased his knowledge of obtaining and using metals and minerals. By the year 1 A.D., people in various parts of the world had come to know of gold, copper, silver, bronze, brass, iron, lead, tin, mercury, coal, and natural gas.

Perhaps even more impressive than the historic fact of the early importance of mineral products in the life of primitive peoples is the frequency with which allegorical illustrative references to the mineral arts occur in the Bible. Outstanding examples of this type are the moral analogy of the potter shaping plastic clay on his wheel, and the proof of purity (of gold and silver) by trial in a hot furnace. The very use of such illustrations is, in itself, acceptable proof that the activities referred to in analogy were not merely known to exist, but were a familiar, intimate part of the people's culture.

As the quantity and variety of metals available to man increased, the power and survival of nations became more dependent upon supplies of these metals. Conquest and trade in neighboring lands became necessary to assure sufficient metal for equipment and weapons. In addition, technology became extremely critical since the tribe or nation with the best weapons always won out in the end. Man found out progressively that bronze made better weapons than copper, iron better than bronze, and steel better than all other metals. Our modern day counterpart would probably be the atomic bomb. As each century went by the mineral economy became progressively more complex.

Looking back at some of the ancient civilizations, we find that Egypt during her years of power was dependent upon the gold and copper of Africa and Asia Minor. Greece financed her wars with the Persians with silver from the mines at Laurium. Alexander the Great was able to march to the borders of India because there was gold in Macedonia. The seafaring Phoenicians were prosperous traders in metals from distant Spain and Britain. The Romans dominated their empire by controlling the tin, lead, iron, copper, gold and silver mines of Spain, Gaul, and Britain (Fig. 2). Each of these once great nations, however, gradually withered and died as their mineral sources were depleted or lost to more progressive countries. Subsequent civilizations, including our modern mineral-consuming age, have been faced with the same conditions. Adequate supplies and wise usage of mineral resources was and still is the key to survival.

Soils: The use of fertilizer materials is as old as agriculture itself. As far back as Roman times the discovery of the use of manures and composts was a mythical event. The value of other materials to plant growth was also known to very early peoples. Lime was used in agriculture by the Celts and wood ashes improved the crops of the Celts, Arabs, and American Indians. Through the centuries these organic and other natural materials were used to improve plant growth, but as the population increased the cultivated lands of the world were called upon to produce more and more. By the nineteenth century it was becoming apparent that concentrated cultivation was exhausting many of the farm lands in the world. Manures, wood ashes and lime helped, but were
not enough to halt the decline in yield per acre. The world was faced with the grim possibility of being unable to feed itself.

Fortunately for the future of mankind, men such as Justus Von Liebig, Theodore de Saussure, J. B. Lawes, J. H. Gilbert, and others had been developing their talents to the basic chemistry of plant growth. In 1844, their efforts were culminated with the analysis that plant life has five major requirements: nitrogen, phosphorous, potassium, organic material, and calcium. Furthermore, they had decided that the traditional natural fertilizers were supplying these essential ingredients, but that the harvested crops were removing more than was being replaced.

The problem then remaining to be solved was how to provide the soil with more nitrogen than it could get from manure, more potassium than it could get from wood ashes, and more phosphorous than it could get from bones. It was not long before it became obvious that the only adequate supply of these elements was from the original source of all soils, minerals. Research soon proved that artificial fertilizers made from minerals were available in quantity, easy to transport, easy to handle, and crop yields increased tremendously.

In the past one hundred years, we have continued to increase our knowledge and use of the artificial mineral fertilizers. Today the United States consumes several million tons of minerals each year to assure adequate food for our ever-increasing population. Nitrates to prevent stunted growth are provided by natural nitrates and nitrogen fixation. Faster growth, increased nutritive value and healthy root systems are promoted by superphosphate from phosphate rock. Plants are healthier, resist disease and spoilage because they get potash from a variety of potassium minerals. The condition of the soil is improved when acidity is counteracted with lime, gypsum, or sulphur.

In addition to the above major requirements, the need for many other elements in small quantities is being recognized. Now minerals are supplying necessary borax, copper sulphate, magnesium sulphate, manganese sulphate, magnesium carbonate, and magnesium oxide. Recently, Dr. Firman E. Bear, president of the Soil Conservation Society of America, announced that molybdenum had been added to the list of elements necessary for plants. Moreover, he stated that as we increase our acre yields the plant requirements for the minor elements will be increased. These minor elements must be supplied to assure the health of plants, animals, and man.

If there is a final solution to the problem of how to feed the world’s increasing population on the limited surface of the earth, much of that answer depends upon the proper use of minerals. Without this, it is impossible ever to attain the necessary maximum growth and yield from the farm lands of the world.

**Forecast:** Of the three fundamental necessities of man—plants, animals, and minerals—the first two necessities can be replaced but minerals cannot. Location of minerals and degree of concentration also is the work of nature. A mine of any type is a wasting asset, each pound of material removed from it reduces by that much the amount that remains to be taken from it. This, fortunately, is not true of animals and plants under any system of reasonable agriculture; these can reproduce their own kind. While the geologic processes which concentrated our mineral wealth in the outer crust of the earth still are in operation, they work so slowly that they can, in the immediate future, affect our stores of
minerals little, if at all. For all practical purposes we must accept the mineral world as a static phenomenon and deal with it accordingly. If the natural processes have not provided us with enough rich deposits of any needed element, we must utilize those of lower grade. If any of these elements are, in the main, so sparsely distributed as to defeat our efforts at supplementing the concentrating processes of nature, we must learn to substitute for them elements more abundant in the thin veneer of the earth's crust which we, at present, can penetrate.

Long since, we would have been forced to use other elements in place of copper had the sciences of geology, metallurgy, and beneficiation remained as they were at the end of the nineteenth century. Today, copper ores, carrying down to 0.75 per cent of copper, are being worked economically. The discovery of such deposits by geological investigation, however, would have been futile had not mining, milling, and smelting techniques been evolved which could treat them at a profit. There is, nevertheless, a limit on the number of such deposits which can be found, even by the most thorough and complete geological exploration. We are also approaching the lower limit of copper ore that can be treated at a profit, no matter how efficient the refining techniques applied to it. While the resources of copper can, then, be greatly extended by a full realization of the potential abilities of geology, mining, and metallurgy, there is a final limit on the supply of copper which we cannot transcend, however skilled we may become.

The position of copper in the scheme of human society is duplicated to a greater or lesser extent for most of the ferrous and nonferrous metals. The supplies of these elements are limited and, despite new techniques of finding and winning them, exhaustion is inevitable. Is this picture one of complete discouragement? Must

we look to the entire decay of our present civilization within a century or so because by then we will have used up our resources of most of the common elements of industry? The answer, of course, is no: There are other sources of supply than the rocks of the earth's crust and even in those rocks there are certain elements which are available in almost inexhaustible amounts when we learn how to recover and, if necessary, to utilize them.

In addition to the rocks of the earth, there is a bountiful treasure of minerals dissolved in the 300 million cubic miles of water in the oceans of the earth. Each cubic mile of that sea water contains 117 million tons of common salt, 6 million tons of magnesia, 4 million tons of potash, 300,000 tons of bromine, 2,200 tons of iodine, 200,000 tons of borate, 900 tons of iron, 450 tons of copper, 70 tons of uranium, 15 tons of silver, about $25,000,000 worth of gold, and lesser amounts of essentially all of the more than 90 elements of which the earth is composed. For a long time to come, it probably will remain cheaper to obtain most of these elements from the rock crust, but the time eventually will be upon us when we will have to extract at least some of them from the sea if we wish to continue to use them. Even now, magnesium and bromine are mined on a large scale from sea water. It is only a matter of time until others will be taken from that source as well; we are only waiting for the technologists who will devise the processes by which it can be done.

Yet much of what we need for our complex industrial civilization probably never can be obtained economically from the sea. The sea contains only 270 billion tons of iron; though this is enough, if every bit of it were extracted, to maintain the steel mills of the United States operating at their present capacity for 2700 years, not for a long time could such a sparse deposit be workable at a profit. Iron is much more abundant in the
earth’s crust than it is in sea water. An average cubic mile of the earth’s crust contains about 5 per cent or 750 million tons of iron, an inexhaustible supply so far as we can foresee, if only we could recover it economically. At the present time iron ore, when mined, runs about 45 per cent iron and plans are being implemented which will permit us to concentrate iron ore prior to smelting so that the grade mined may be lowered to about 25 per cent. This is a great step forward but does not enable us to mine more than a very few of the cubic miles of the earth’s crust. If we are further to tap the huge but sparse reserves of iron of even lower grade, further improvements in milling and smelting must be made or the economy must be adjusted to a higher price for steel or to the substitution of other abundant and easily recovered metals for it. Aluminum or magnesium seem most likely to meet the requirements. Our proved and potential reserves of these elements in minable grade are immeasurably greater than those of iron (unless there is a revolution in metallurgy), particularly when the availability of magnesium from sea water is considered. But before we can change our civilization from the steel age to that of the light metals, there must be tremendous changes in the metallurgical and fabricating industries. However, the problems presented are no more insoluble than those which faced the infant scientific and technical world at the beginning of the Industrial Revolution.

A conversion to an age of light metals still is far in the future and many more immediate problems must be met, such as the insufficient resources in the United States of “strategic and critical minerals,” for example, antimony, chromium, cobalt, columbium, ferro grade manganese, mercury, mica, nickel, optical grade quartz, tin, tungsten, bauxite (aluminum ore), cryolite, asbestos, graphite, platinum, vanadium, and industrial dia-

monds. Many minerals from which these metals and minerals are produced are present in this country in scattered, low-grade deposits which at present do not constitute ore. So far as these are concerned, the geologist has done his part. The deposits are known but geological processes have failed to concentrate them to the degree necessary for economic extraction. If they are to be utilized, if we are to avoid the labor and expense of developing substitutes for them, mineral engineers and technologists must point the way to their profitable recovery. Such projects as the extraction of aluminum from alunite and clay, and of magnesium from dolomite must be perfected. Perhaps it will be possible to lower even further the grade of minable ore of a number of metals, particularly iron, thereby greatly increasing our reserves. Further study may make it possible to utilize the low grade but extensive sedimentary deposits which contain small, consistent amounts of such elements as uranium and vanadium. But, for some of our industrial metals, substitutes sooner or later must be found. Fortunately the process is one that probably can be approached gradually; not all elements will be exhausted or denied to us at one time. Each problem is one which challenges the technologist to discover a satisfactory substitute, the metallurgist to produce it, the geologist to find the ore, and the mineral preparationist to concentrate it.

Oxygen, nitrogen, and other mineral elements are mined from the atmosphere. The fixed nitrogen process upset the economy of Chile at the close of World War I. Neon, one of the five rare elements in the atmosphere, is recovered in commercial quantities in spite of the fact that it makes up only 0.0018 per cent of the atmosphere by volume. The cost of extracting oxygen from the atmosphere has been reduced drastically during the last war. As a result this element is finding many new
uses, particularly in the metallurgy of steel, and many combustion operations may become large consumers with increased economy.

We stand then, on the threshold of a period of industrial change in which new methods and techniques must be gradually but surely developed to adapt our industrial and economic life to fit what we can find and make available the wealth the earth contains. There are certain basic facts of mineral supply which we cannot change but, within these natural limits, there is an abundance of minerals which can and will serve our needs as we develop our abilities to use them. Since many minerals, albeit not always the ones easiest and cheapest to use, are inexhaustible and since the past achievements of the human mind are but the barest indications of what it can accomplish in the future, we are capable, if we but will, of adapting the earth to our purposes indefinitely. The raw materials—minerals—are available without end.¹

Conservation: Man is as parasitic as all other animals who prey on our plant and animal kingdoms, generally paying no attention to replacement. He preys also upon our mineral resources which are irreplaceable, and which in many cases are wastefully exploited. Too often the mineral extractive industries are considered on a basis of feast or famine. Such a situation cannot continue long since the days of easy and cheap acquisition of our natural resources are passing rapidly.

The natural elements make up this planet, and almost all of them occur as metals or as metallic and non-metallic minerals, rather than as animal or vegetable compounds. Mineral is neutral material, not a resource until useful. In spite of all of the initiative, technologies,


skills, and teamwork, man uses only 300 of 1400 known minerals; he is now on the threshold of a synthetic mineral age.

Nowadays we are less sure of geologic hypotheses. Economists mislead the public because they do not understand the science of geology as related to the determination of mineral reserves. On the other hand, the great hope lies in inaccessible areas, extension of known deposits, and in submarginal deposits.

Coal, petroleum, and natural gas have been exploited wastefully in many cases. It was thought at one time that supplies of these materials were inexhaustible, but it is now realized that this is far from the truth. But it is a tragedy in some ways that we have not invested more time and energy in coal utilization . . . particularly when we recall the tremendous, needless waste of heat, steam, power, or fuel. To be sure we have made some marked progress in coal utilization, but not very much in the domestic field. In spite of atom-splitting possibilities,¹ there is no prospect of the organic mineral fuels going out of business.

Remarkable as have been the results of the Government project on atomic fission and nuclear energy, it is perhaps in order to mention that $2,000,000,000 represents a lot of effort. If a comparable amount of effort were put on our present sources of energy, especially the mineral fuels, the results might be less spectacular but they might be infinitely more useful as far as peacetime developments are concerned.

Forests have been cut down with very little thought of reforestation. Our soil gave forth bounteous produce with very little contribution to it on our part. It was exploited with little thought of the future. It is known that the soil must receive in order to give. Soil conser-

vation has become a necessity instead of an academic consideration or a fad.

The history of wasteful exploitation of all reserves teaches us that we must establish a far-reaching, well-planned conservation policy. We must do more than establish such a policy. It must be translated into action and applied effectively and energetically to the residue of our original inheritance. Consideration must be given to the needs of the future instead of what is expedient for the present with the hope that the future will take care of itself.

Our thinking on our natural resources should be changed in some respects. Owners of resources should be considered custodians. Resources should be exploited to gain the "greatest happiness of the greatest number," as expounded by Bentham, English philosopher and jurist. The maximum profit gained in the shortest interval may not be in the best public interest in the long run. The examples of wasteful exploitation already cited, and many others, serve to illustrate this point.

A conservation policy should require that all resources be managed by the most efficient methods available. Coupled with a conservation program, an inventory is needed of known reserves. Prospecting, especially subsurface, should be carried out to find new reserves, keeping in mind future needs. Existing techniques of exploitation should be improved to utilize the leaner sources. The financial resources of private enterprise cannot be put to better use.

Just as sections of this country are dependent on other sections for certain essentials, so are countries dependent upon other countries for certain natural resources. An exchange of goods or services accompanies this transfer of resources, and we need to expand the facilities by which such exchanges may be carried on peaceably and to the benefit of all on an international scale, just as it is performed on a national scale. Nations need not be have-nots in certain items when they are members of the family of nations, any more than a state in our union need go without coal because there is none within her borders.

The artificial barriers set up between countries which restrict the exchange of resources and products should be so adjusted that standards of living may be raised all over the world; then there will be no need to acquire markets and resources by war.

Man as an individual is inseparable from his fellow man, and his own problems and welfare are integrated with the problems and welfare of the rest of the world. He tends to forget this in his struggle for survival and his desire for security and freedom from fear and want. This produces selfishness to the extent where it may deprive others of some of the essentials of life. It is the law of the jungle on a vastly expanded scale and holds on an international as well as on an individual scale.

Such a ruthless philosophy will lead to the destruction of man and his veneer of so-called civilization. Are we fundamentally cave men or do we believe the teachings of some of our great philosophers that we are our brother's keeper? Not keepers in the sense of pauperizing him, but in the sense that brothers co-operate for the common good.

The gradual change from the laissez-faire economy to a balanced economy must be accelerated. It is expensive and socially disastrous to have periodic cycles of prosperity and depressions in a land bountifully endowed with resources.

For stability our economy must be partially planned. Inventories should be made of our material and human resources. Our needs for goods and services should be determined, the availability of manpower to satisfy these needs can be ascertained, and a balance made between
the two needs for full employment. This is only expanding what is done on a family scale to a national and possibly an international scale. Such planning need not destroy individual initiative as has been claimed by opponents. Ability and effort can still be rewarded under such a system just as in the past. Free people under free economy can participate in common wealth. But the books must balance. Printing presses cannot pay the bill. We must think once more in terms of the fundamental products of Mother Earth. And a return to work, thrift, the Golden Rule, would be the greatest blessing that could happen to all of us.

The powers that be must have foresight to plan effective world control of the high-grade minerals in the lithosphere. Planners must hold to bedrock truths. Mineral economists sat at the peace table at the close of World War I, but their advice fell on deaf ears. The importance of minerals to national security has received increasing recognition in the post-World-War-II period as is demonstrated by the Strategic and Critical Materials Stock Piling Act of 1946 and the National Security Act of 1947. The National Security Resources Board, a part of the Executive Office of the President, has, among other functions, that of advising the President concerning the coordination of military, industrial, and civilian mobilization, including policies for establishing adequate reserves of strategic and critical materials and for the conservation of these reserves. Mineral economics could be admirably represented in Washington but thus far it is enmeshed in the conflicting currents of national and international politics, scheming, and intrigue.

Both business and labor must realize their stake in this plan. There should be fair profits and wages with no jockeying for position to gain temporary advantages and create inflationary spirals. Deflation is bound to follow with harm to all. It would seem that our ideas of money should be modified to the concept that it is merely a medium of exchange, a convenience necessary to establish commodity flow. It is the means of exchanging the fruits of your labor with those of your neighbor.

The planning of economy on a national and international scale requires that we know our neighbor, appreciate his abilities and capabilities, and realize the contribution he can make to the common good. His rights should be respected. At the same time we must all be ready to assume our responsibilities. Do not let the other fellow do it—we are the people, and the people can make this world in their own image. The choice is between selfishness and greed, the destruction of our neighbors and ourselves, or a spirit of "help others to help themselves" with a resultant age of peace and happiness for all.

CONCLUSIONS

There is no simple answer to the question, "What is the meaning of life?" The expressions of life are so multiple that life has different meanings for different spheres of thought, such as art, science, or philosophy; and it conveys a different significance to different persons, according to their individual development and interests. Life is complex from a philosophical point of view. The meaning of life is superficially positive and unmistakable only when approached from a mechanistic viewpoint; namely, that of biology or biochemistry, since these deal with the physicochemical basis of life processes.

However, such a purely mechanistic or biochemical approach to the significance of life and the interpretation of man's behavior on the basis of purely physical
laws is certain to run into trouble. Similarly, a concentration of effort upon materialistic advances in world progress is extremely dangerous. The possible consequences of splitting the atom, development of guided missiles, and possible bacterial warfare are timely examples.

Man becomes more self-reliant as he extends his scientific and technologic discoveries and learns how to shape natural conditions to his own desires. When man will be able to travel to other planets in atomically propelled space ships and destroy whole worlds by pushing a button, a possibility which now seems to be within the realm of the predictable future, he will need the strongest power of self-control to survive. Whereas primitive man was at the physical mercy of nature, modern and future man will be to a large extent at his own mercy, or rather at the mercy of his own mental and spiritual shortcomings. It may be seen clearly in all recorded history that there is an Absolute Justice and that progress should proceed in this direction. A person, tribe, or nation who disregards it does so at his or its own ultimate risk and peril, as has been demonstrated by World War II.

What are the prospects of man’s rising to the proper spiritual level and progressing in the future in the right direction? These prospects are not exactly encouraging, at least if history teaches us anything. As Schopenhauer said, “Man may do as he will, but not will as he will.” Let us hope that humanity’s fate will not be so bleak as predicted by this great pessimist, but it remains true that the lack of proper spiritual value and rampant irresponsibility are the greatest enemies of mankind. Irresponsible men and women are just as dangerous as the atomic bomb, and there are many more of them. If humanity is to survive, and particularly our democratic form of society, men and women must learn that there is a purpose in life other than having a good time; that obligations and duties go hand in hand with rights and privileges; and that it is necessary to make sacrifices for the common good. Otherwise, we may follow the fate of ancient Greece whose extraordinary physical prowess and intellectual brilliance could not prevail against a doom caused by moral irresponsibility.

Progress must be of a balanced nature, and mankind’s goal is many-sided perfection. Life should point toward individual perfection and creation, which will lead to greater collective perfection and creation, and is as much of mind and spirit as of matter. This process goes on while life exists and may continue long after the physical ego has declined or disappeared, since the spirit and ideas it has created or conveyed may persist and evolve indefinitely. Are not the ideas of the early thinkers of mankind immortal? The thoughts expressed by those great men survived centuries after their physical death. Thus, man, living matter as he is, may become immortal through the individual’s spiritual perfection and contribution to creative thought.

But the question of force must be settled before man can hope to progress to the brighter goal. He must establish in his own conscience the fact that he can continue to exist only through his existing with and for other men. If man can eradicate all ideologies of force, and establish a smoothly, interwoven network of nations that can live tolerantly and co-operatively, then man may anticipate a future where nuclear energy, from one source or another, will increase the production of plants and animals, ease human labor, and lengthen the life span of the human race. On the other hand, nuclear energy might offset any unequal distribution of natural resources, thus provide equal opportunities to all the peoples of the earth, and lessen the evil of nationalistic rivalries, imperial exploitation, and economic warfare.
What, then, is perfection and how can it be achieved? In what ratio does man believe in ideas, things, fellow men, economic symbols? We are considering here a concept that cannot be generalized or turned into a dogmatic precept. Ultimately, it is a function of the spiritual state and achievement of the individual which must be integrated on a community, national, and international scale. Understanding, maturity, perfection, strain, adversity, and suffering are physical and emotional elements that the individual must face and overcome in the process of his evolution. This consideration remains true for material and spiritual achievement and perfection.

Thus, adversity and pain become the crucible in which the spirit and mind acquire that impersonal detachment, maturity, and understanding which are so necessary to guide man's thoughts and actions into the right channels.

The limits imposed by nature upon the single individual are still very great and will always be great. If man wants to achieve perfection, he must learn that, in addition to those natural limitations, he must also impose upon himself additional spiritual limitations in order to help his fellow man rather than ruin him.

It is in this field that the importance of education becomes apparent. Young men and women must be taught that the "pursuit of happiness" as commonly understood (meaning power, money, and pleasure) must never be an end in itself. Nature is certain to oppose us vigorously at some time in our life, and we must be spiritually prepared to accept such blows. What is more, we must be willing to perform our duties as decent members of the human race even before we learn, from cold and unkind fate, that there are many great eternal truths besides hedonism, cynicism, and arrogance.

The Western Hemisphere desperately needs about fifteen quality, unified Mineral Industries colleges,¹ eight in the United States, two in Canada, and five in South America. The purpose of these schools should be not solely to train potential human resources in the use of scientific and technological devices, or in the ability to create bigger and better machines and devices, or in the capacity to solve nature's secrets and discover nature's laws and the ways to control them, but to produce a better and more decent citizen for a great democracy, a man who will be able to use his training and brains with proper self-control and humility in order to improve the fate of all mankind.

The roots of human progress are in education. The future of the world depends upon how successfully educators carry out this trust. Literacy cannot be defined in terms of reading and writing. We must not plunder Mother Earth. "Where there is no vision, the people perish."

---