SCIENCE

VOL. 88 FRIDAY, OCTOBER 14, 1938 No. 2285

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal
Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

WORLD NATURAL RESOURCES[1]

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INTRODUCTION

It will, I think, be obvious that a subject as broad as that assigned to me to-night can not be fully treated in the time at my disposal. I therefore propose in the first place to review, very briefly, the fundamental resources that nature has placed at man's disposal; subsequently I shall discuss, at somewhat greater length, the adequacy or inadequacy of those resources to provide the requisites for food, clothing, shelter, heat and power.

It will not be sufficient, however, to consider the world's natural resources from the point of view of present methods of utilization alone. Resources in which we were not interested yesterday are of vital importance to-day; the useless or inert of to-day may to-morrow, through the contributions of science, profoundly affect the welfare of the human race.

To take only one example of how science and technology have made available a natural resource that probably would not even have been listed as such fifty years ago, let us consider the nitrogen of the atmosphere. Our knowledge of nitrogen as a plant and animal food goes back only about one hundred years. Research during the latter part of the nineteenth century demonstrated that the ultimate source of nitrogen was the air, from which it was derived through the action of micro-organisms in the soil, and atmospheric electricity. These, however, were natural agencies, over which man had little control, and in order to restore the depleted nitrogen of the soil he was dependent upon the application of animal wastes, nitrates obtained from certain natural deposits, and ammonia recovered as a by-product in the cooking of

[1] Paper presented June 27, 1938, before the American Association for the Advancement of Science, in the series on Science and Society.

coal. Although such supplies were of a substantial character, they were recognized as insufficient for the ever-increasing population of the world, and the problem of obtaining an adequate source of nitrogen was the cause of much concern.

Then came, in the first fifteen years of the present century, the development of the electric arc, the calcium cyanamide and the ammonia processes of nitrogen fixation, as a result of which nitrogen in cheap and convenient form became available in any quantity desired. This removed, for all time to come, the possibility of a world shortage.

This is but one illustration of the rôle of science in finding a complete solution to one of the major problems of food supply. Since at no period in the world's history has science been so active as it is to-day, I believe we may rest assured that where the fundamental resources exist in nature, man will eventually find the means for their utilization.

FUNDAMENTAL RESOURCES

In the ultimate analysis, we are dependent upon the abundance and availability of the different chemical elements in the world's crust, the ocean and the atmosphere. It will therefore be of interest to examine the magnitude of our natural resources as they exist in these major reserves.

TABLE 1

ESTIMATED COMPOSITION OF THE EARTH'S CRUST

Metals				Non-metals	
	Per cent.		Per cent.		Per cent.
Aluminum	7.96	Nickel	0.023	Oxygen	47.77
Iron	4.44	Strontium	0.02	Silicon	27.25
Calcium	3.51	Chromium	0.01	Hydrogen	0.22
Potassium	2.48	Copper	0.0075	Carbon	0.19
Sodium	2.47	Zinc	0.0040	Phosphorus	0.10
Magnesium	2.28	Lead	0.0020	Sulfur	0.10
Titanium	0.47	Silver	0.00001	Fluorine	0.10
Manganese	0.09	Gold	0.0000005	Chlorine	0.01
Barium	0.08	Others	0.20	Others	0.21
			24.05		75.95

Table 1 lists separately the principal metals and non-metals in the order of their abundance in the crust of the earth. It will be observed that the most common metal is not, as one might suppose, iron, but aluminum, which constitutes approximately one thirteenth of the earth's crust, as against one twenty-second for iron. These metals, as well as calcium, potassium, sodium and magnesium, exist in such enormous quantities that we need never fear that a shortage will develop. It is interesting to observe that the so-called "common" or "base" metals, copper, zinc and lead, are present to the extent of less than 0.01 per cent. each. Fortunately, nature has so concentrated them, and man has so thoroughly worked out their metallurgy, that they are cheaply available to the present generation. Their future, however, is somewhat obscure, for the known commercial deposits of these metals will nearly all be exhausted in the next 100 years, and most of them in less than half that time. No doubt other deposits will be discovered, particularly as the world's geology becomes more thoroughly worked out and scientific methods of prospecting for ore deposits are further developed. It may be expected, however, that sooner or later recourse will be had to deposits of lower grade, not now considered as ore, also to the increasing use of scrap metal and to the partial substitution of the commoner metals for those that are approaching exhaustion. In this connection, the enormous increase in the output of metallic aluminum during the past three or four decades is significant, as is also the still more recent commercial production of magnesium at relatively low cost.

Looking at the list of non-metals, some may be surprised to observe that oxygen and silicon together make up no less than 75 per cent. by weight of the earth's crust, in which, however, both of these elements exist only in combination. All the other nonmetals listed also exist in quantity sufficient for both present and future needs. Even chlorine, given as 0.01 per cent., constitutes 60 per cent. by weight of common salt, of which there is no scarcity. Before we leave this subject, it should be noted that potassium and phosphorus, the bases of essential plant foods, are to be classed with the abundant elements.

Table 2 gives the quantities of the principal elements in solution in sea water, expressed as tons per cubic mile. Since sea water is at the door of virtually every country in the world, none of them need fear a shortage of these elements.

Last summer in California I visited the first commercial plant to recover magnesia from sea water; several others are now under construction or contemplated. Bromine, though relatively scarce, is recovered to the extent of about 15,000 tons per year in two commercial plants—approximately the quantity contained in one twentieth of a cubic mile of sea water. Even iodine, though present to the extent of only one part in 23,000,000 of sea water, amounts to 200 tons per cubic mile, and since the ocean is estimated to contain 300,000,000 cubic miles, the total quantity available in this natural reserve is no less than 60,000,000,000 tons.

The third main reserve of the elements is the atmosphere, the composition of which is shown in Table 3. Quantities are given in tons per square mile, and since there are about 200,000,000 square miles of the earth's surface, it is obvious that a nitrogen famine is not imminent! It is reassuring to find so much carbon dioxide, upon which all plant life depends; this is of course being returned to the atmosphere, through the oxidation of carbon, at substantially the rate of ab-

TABLE 2

Elemental Reserves in the Ocean

	Tons per cubic mile
Chlorine	90,000,000
Sodium	53,000,000
Magnesium	5,700,000
Sulfur	4,300,000
Potassium	3,300,000
Calcium	2,400,000
Bromine	310,000
Iodine	200

sorption by vegetation. The ocean, which dissolves carbon dioxide, and the atmosphere, in which it exists as a gas, together constitute a giant balance wheel, which takes up any variations in the natural cycle of plant growth and decay. The rare gases in the atmosphere are of more than passing interest, since these are already finding some practical applications, as, for example, in neon signs.

TABLE 3

Gaseous Reserves in the Atmosphere

	Percentage by weight	Tons per square mile at sea level
Nitrogen	75.474	22,269,000
Oxygen	23.200	6,845,400
Argon	1.283	378,600
Carbon dioxide	.040	11,800
Neon	.00125	370
Hydrogen	.00070	207
Krypton	.00029	86
Helium	.00007	20
Xenon	.00004	12

Food

Just 140 years ago Malthus published his first essay dealing with what he believed to be a tendency for the world's population to increase faster than the means of subsistence. His ideas were widely accepted, and in the years that followed there were many who envisaged a time, in the not very distant future, when the world's population would increase to such an extent that an acute shortage of food would develop.

Let us look for a moment at the situation in the time of Malthus. Plant food was known to exist in the soil, but this quickly became depleted by continuous cropping. What could be more logical than to conclude that when all the cultivable land had been occupied the peak of food production would have been reached, and as further crops were removed the productivity of the soil would decrease?

One can scarcely blame Malthus and his followers for not being able to predict the solution of the immediate problem through the contribution which science would make to society. Since Malthus's time, potash has become available from the Stassfurt and other great deposits of potassium salts; soluble phosphates have been manufactured by treating natural rock with sulfuric acid or by appropriate furnace methods; nitrogen has been obtained from the various sources already mentioned. As a result, conditions have been completely changed in spite of the rapidly increasing world population.

As yet, only a beginning has been made in increasing food production. Every one familiar with scientific agriculture knows that a major increase in crop growth could be brought about, on the present acreage, by the more liberal application of potash, phosphoric acid and nitrogen and by the neutralization of natural acids. The elements iron, calcium, sodium, magnesium, manganese, zinc, copper, cobalt, sulfur, chlorine, iodine and boron are now all recognized as plant foods, or animal foods derived from plants, yet very little has been done towards determining the requirements of soils with respect to these elements and making the necessary additions. There can be little doubt that human and animal food supplies could be doubled or tripled if all necessary plant foods were applied in abundance.

Malthus believed, and it has often been stated even in recent years, that the soil is the world's most valuable natural resource. Actually, in view of the ease with which ordinary soil is depleted, we should regard it rather as a convenient medium through which nutrient can be made available to plants. As such it is of inestimable value, but Gericke has recently demonstrated in California that soil is not essential, for he has developed the new art of "hydroponics," or the growing of crops in nutrient solution without soil. It is of interest to note that tiny Wake Island in the Pacific, only half an acre in extent, is the newest hydroponic farm, and that crops will be grown there for the passengers and crews of transpacific Clipper planes. May this not be a picture of the intensive farming of the future, if the world's population should increase to the point where the cultivable areas of the earth's surface are too limited in extent?

The progress of the plant breeder has been another major factor in deferring the time of distress predicted by Malthus. The development of early-ripening varieties of wheat, for example, has pushed well to the north the zone in which this most important cereal can be grown, a zone, be it noted, extending around the world where land areas are greatest. An equal triumph has been scored in the breeding of rust-resistant varieties of wheat, now for the first time available in large quantity. In 1935 the loss from rust in western Canada alone was officially estimated at fully 100,000,000 bushels of wheat, and on the average the loss would amount to at least 25 or 30 millions annually. Within five years the losses from wheat rust should be substantially eliminated from all countries of the world.

Recently research has been organized on the destruction of weeds, the losses from which in the United

States have been estimated to amount to more than those from insects and all plant and animal diseases combined. Improved cultural practices have already been evolved, chemicals have been found that will destroy undesirable vegetation, and even some that will selectively kill certain annual weeds and leave cereal crops substantially undamaged.

The advances in plant and animal pathology have been scarcely less remarkable than those in breeding. One need only mention a few—the chemical disinfection of seed grain and potatoes, the control of hog cholera, the reduction of tuberculosis in cattle—to realize the importance of these developments. Further, there is a growing recognition of the fact that a number of plant and animal diseases are not caused by any specific organism, but are the result of deficiencies in food supply. For example, the application of a small amount of boron to soil prevents drought spot and corky core of apples and alfalfa yellows; the administration of a minute trace of cobalt prevents a serious deficiency disease of sheep.

I would remind you, too, that our food supplies are not derived entirely from land areas, but also from water areas, which constitute some 75 per cent. of the total surface of the earth. The world production of fish now amounts to nearly 15,000,000 tons per year, or about 15 pounds per person. Japan alone has over 1,000,000 persons employed in fishing.

The subject of food resources would be incomplete without mention of what, if it eventuates, may prove to be an accomplishment of the most far-reaching importance. Chemists have already synthesized thousands upon thousands of complex compounds; if they are successful in commercially synthesizing carbohydrates for human and animal food, they will have achieved their greatest triumph, and that is a feat the possibility of which can not be lightly dismissed.

CLOTHING

Probably the earliest type of clothing worn by mankind consisted of the skins of animals, and one can almost picture the Malthusians of that day predicting the time when the world's population should have increased to such an extent that insufficient furs and skins could be obtained. As a matter of fact, that period would have arrived relatively soon, but for the existence of plant and animal fibers and the development of the art of weaving. By that technological advance a clothing shortage was indefinitely postponed.

But what of the future? If the world's population is doubled or tripled, will there be sufficient raw materials to provide clothing for all? Let us consider our present resources.

Cotton is by far the most important textile fiber, its annual production being about three times as much as that of all others combined. Without examining in detail the production of the major cotton-growing countries we may note that the United States grows just about half of the world's production, and this on 30 or 40 million acres, or say 2 per cent. of the total land area of that country. If the demand were to arise, cotton could be produced sufficient for three or four times as great a world population as that of the present, without making any serious inroads on the areas required for food production.

A similar situation exists in regard to wool. The single island of Australia now produces 25 per cent. of the world's wool, and could produce on an even larger scale. Great Britain and New Zealand both have an average of more than 200 sheep per square mile; Canada has only one! I would not wish to imply that all countries could equal the record of these two, but in Canada, for example, at least a tenfold increase in sheep population would seem quite feasible.

But we are no longer dependent upon natural fibers, for in the last 25 years the problem of the commercial production of synthetic fibers has been solved, and a great new industry has sprung up. In 1920, for the first time, the production of rayon in the United States exceeded 10,000,000 pounds; in 1937, it was more than 300,000,000. The world production in 1936 was 1,303,165,000 pounds, yet this is one of the newest industries. Thus, through developments in science and technology, an entirely new resource for the manufacture of textiles has been provided, one sufficient to clothe untold millions of people.

But rayon is not to be permitted to monopolize the field of synthetic fibers. For several years a so-called "artificial wool" has been made in Italy from casein, a product of skim milk. Now reports come from Japan that a similar fiber has been made there from soybean protein. While the present product appears to be definitely inferior to natural wool, it must be remembered that the first rayon was so weak as to give rise to the prediction that no large market for it would ever be developed.

SHELTER

The problem of shelter has been a live one since the earliest days of the human race. Primitive man took refuge in caves to protect himself from the cold, the rain and the attacks of wild beasts, but the number of suitable caves was very limited, and history bears mute record that competition for them was keen. Doubtless man, with his rude weapons, frequently came off second best in the conflict which took place for their possession.

With the development of the simplest wood-working tools forests became the major source of raw material for the provision of shelter. For thousands of years this invaluable resource has been used as lavishly as if it were inexhaustible, and indeed this is even to-day the situation in many countries. In Canada, for example, the forests are being destroyed—by man, insects and fires—some two-and-a-half times as fast as they are grown. The United States, although possessing not more than 10 per cent. of the total forest stand, is responsible for approximately 40 per cent. of the world's cut.

Nevertheless, the situation is not by any means hopeless. There are still vast forest areas, estimated to be as much as the area of the whole of North America plus Australia. The approximate distribution of this area is shown in Table 4, from which it will be evident that about two thirds of the total is in the possession of four of the world's political units, the U.S.S.R., the British Empire, Brazil and the United States. The Scandinavian countries and some others with relatively small area have had the foresight to institute scientific forest management, under which the forests are placed on a permanent basis and made to yield an annual crop.

TABLE 4

WORLD'S FOREST RESOURCES

	Percentage of the world's forest area
U. S. S. R.	21.1
British Empire (40 per cent. Canadian)	21.0
Brazil	13.4
United States	9.1
France and dependencies	3.9
Argentina	3.5
Japan	1.2
Germany and Austria	0.5
Italy and Abyssinia	0.4

The world's annual growth of wood is about 38,000,000,000 cubic feet. If all forests of the world were properly protected and given reasonable care, it is estimated that they could produce annually 350,000,000,000 cubic feet. It is thus evident that an appreciation of the seriousness of the situation, coupled with the general application of scientific methods of forest protection and growth, would provide for the needs of a population much greater than that of to-day.

Man discovered at an early date that excellent shelter could be secured by using mineral raw materials. Rock could be built up into substantial walls; clay dried in the sun became hard, and in desert countries afforded sufficient protection against the elements. Burnt clay blocks, or brick, became cheaply available. Clay being one of the most abundant of all mineral reserves, the potential brick supply is unlimited.

Concrete has become one of the major building materials. Gypsum products are now being applied in a wide field. Further, new materials, such as glass blocks, stainless steel and enamelled iron, are being introduced, providing variety in appearance and a wide range of physical properties. Nor has nature apparently fixed any limit to the quantities of such materials that may be used for the provision of shelter.

HEAT AND POWER

The major present sources of heat and power are coal, oil, natural gas, wood, peat and the energy of falling water. The use of wood and water power date back to prehistoric times. Coal was possibly used in China 2,000 years ago, but its use in the western world did not begin on any considerable scale until the latter part of the thirteenth century. As late as 1306, Edward I of England compelled all except smiths to cease burning coal and revert to the use of wood.

Table 5 shows the coal reserves of the world, as compiled by the International Geological Congress of 1913. It should be explained that, in the compilation of these reserves, all countries were asked to include seams of economic value one foot or more in thickness and not more than 4,000 feet from the surface, and in addition coal in seams two feet or more in thickness and at depths between 4,000 and 6,000 feet. No allowance was made for mining losses, which are very heavy. The figures therefore should be taken as a very generous estimate of the minable coal of the world.

TABLE 5

COAL RESERVES OF THE WORLD

	Millions of metric tons
United States	3,838,657
British Empire	1,729,105
China	995,587
Germany and Austria (1913)	477,232
U.S.S.R.	173,879
France and dependencies	37,585
Japan	7,970
Italy	243
World total	7,397,553

The most striking thing about these figures is the uneven distribution of coal reserves throughout the world. More than half of the total is in the United States, and 73 per cent. is in North America. Canada's proportion is about 17.5 per cent., or three quarters of that of the British Empire. Nevertheless, the reserves in China, Germany, U.S.S.R. and France are so large that no concern need be felt for a long time to come regarding the exhaustion of those deposits. Considering the world as a single unit, it may be observed that the tonnage of coal is so large that at the maximum rate at which it has yet been mined it would last for about 5,000 years. Even if the minable coal be half that quantity and the rate of mining should substantially increase, it is obvious that the supply is adequate for many hundreds of years. If, on the other hand, we take a backward look, a period of 2,000 years carries us only to about the beginning of the Christian era, and the world's coal reserves must be regarded as possibly exhaustible within a similar period.

The present production of oil and gas is derived chiefly from the United States, which is responsible for some 60 per cent. of the world's total, and uses a correspondingly large proportion.

I shall not attempt to show the world's reserves of petroleum or natural gas, because these are so difficult to estimate. Twenty-five years ago it was predicted by some authorities that the reserves of petroleum would be substantially exhausted by the present time. Yet, in spite of an enormous increase in consumption, the supply seems greater than ever. Vast areas remain virtually unexplored as sources of oil and gas. Nevertheless, the known reserves are being depleted at such a rate that one can not with much confidence predict a natural supply sufficient for more than 50 or 100 years.

Even though the present deposits of crude oil be exhausted, however, there need be no shortage of liquid fuel. In many parts of the world there are large deposits of oil shales, which, though not ordinarily minable at a profit under present conditions, constitute a large potential reserve of oil. In Alberta, there is an enormous deposit of tar sands, extending over thousands of square miles, and it is estimated to contain sufficient bitumen to supply the world with oil for centuries. Further, motor fuel can be readily produced by the hydrogenation of coal and cellulose, and both methyl and ethyl alcohol can be used in internal combustion engines. One need therefore feel no anxiety for a long time to come about the world's liquid fuel supplies.

Wood and peat are still available in large quantities as fuel. The former has already been discussed, but it may be pointed out that its use as fuel is decreasing in most countries, although over large areas it will long continue to be an important local fuel. Peat deposits are all of a shallow character, and, although of considerable importance as a domestic fuel reserve, peat is not likely to be used on a very large scale.

It is almost equally difficult to obtain reliable figures regarding the water power available throughout the world. One authority gives the total water power of the U.S.S.R. as 3,000,000 horsepower; another makes an estimate of 165,000,000 for Asiatic Russia alone. The total for the British Empire is about 68,000,000 horsepower, of which approximately half is in Canada. That of the United States is about 55,000,000, of Norway and Sweden 22,000,000. Many of the great waterfalls of the world are remote from industrial areas, as, for example, Victoria Falls in Central Africa, the available horsepower of which has been estimated at 35,000,000, or five times that of Niagara. The total available water power of the world at an average six-months' flow is probably not less than 400,000,000 horsepower and may be substantially more.

Water power has a great advantage over most of the resources so far discussed in that it is, ordinarily speaking, of a permanent character and therefore inexhaustible. Nevertheless, the utility of any waterfall depends largely upon the amount of its minimum flow, which, for maintenance at a high level, requires regulation. Regulation is accomplished to a large extent in nature through the existence of forest areas and limited drainage; man has a tendency to cut the forests and drain the land, thereby accentuating both the maximum and minimum flow. Care must therefore be taken to see that even this valuable resource is not destroyed.

Two sources of power that have not yet been drawn upon heavily are winds and tides. The total amount of wind power is enormous, and its distribution is world-wide. On the other hand, its utilization is relatively costly and the supply is intermittent. Winds may become an important source of power as coal and oil reserves approach exhaustion, particularly if the cost of the storage of power to provide for periods of calm weather can be reduced. The tides are also a potential source of much power, but conditions on most coasts are not favorable to their utilization.

All these resources of heat and power have been, or are being, derived indirectly from the radiant energy of the sun. To use the sun's energy directly has long been the dream of inventors the world over, and a number of them have been technically though not commercially successful. A new attempt is now to be made, this time on a more comprehensive scale, at the Massachusetts Institute of Technology. Physical and chemical methods are to be tried, and also a biological method through the speeding up of the growth of trees.

The total quantity of heat derived from the sun's rays is enormous. President Compton, of the Massachusetts Institute of Technology, illustrates this by pointing out that in the temperate zones, during the three months of greatest sunshine, each acre of land receives the heat equivalent of about 250 tons of good coal. From this it is evident that the proportion of the sun's heat normally utilized in the growing of vegetation must be extremely small.

The heat of the earth's interior has often been mentioned as a potential source of power, and steam escaping from the ground near active volcanoes is already being used on a small scale. In most parts of the earth's surface, however, the temperature increase with depth is so slow as to offer little encouragement for the utilization of the heat of the interior.

Reference has often been made in the literature to the enormous stores of energy locked up in atoms, and attention has been called to the automatic decomposition of radium to form elements of lower atomic weight. Undoubtedly there exists within the atoms an exceedingly high concentration of potential energy, but doubt may be expressed as to the likelihood of its utilization. I believe it was the late Dr. Slosson who referred to this source of heat and suggested that if man were ever successful in developing it he would find it difficult to control. The success of his experiment, Slosson thought, would be announced to the universe at large by the appearance, in the place now occupied by the earth, of a new star.

Miscellaneous Materials

A vast assortment of raw materials is drawn upon to meet the requirements of industry, whose purpose it is to provide man with the necessities of life, to satisfy his craving for pleasure, and, be it said to his discredit, to give him those facilities used for the destruction of his fellows. I have already dealt with most of the necessary raw materials, and reference need be made here to only three—iron, rubber and paper.

It has been pointed out that of the metals iron is second in abundance only to aluminum. The ultimate availability of this metal is therefore sufficient permanently to provide for the needs of mankind. In view of the dominant position of iron amongst the metals it is worth considering the magnitude and distribution of the world's reserves.

The maximum world production of pig iron in any one year may be taken as 100,000,000 long tons, which was the figure for 1937. It is estimated that the positive iron ore reserves of North and South America could supply the world's requirements at this rate for 40 years, and the probable reserves are sufficient for an additional period of 320 years. For Europe the corresponding figures are 50 and 160 years.

Other countries also have large reserves, but none comparable with those given. The total positive and probable resources of the world are sufficient at the present rate of consumption for about 600 years. This is a highly satisfactory situation, especially in view of the fact that enormous tonnages of lower-grade material are known to exist, and the probability that other large deposits will be discovered.

Rubber grows wild in a number of tropical countries, but the major production is now derived from plantations, where rubber trees are grown in a systematic way. The peak of rubber production was reached in 1929, with 863,410 tons. This would require 10,000 square miles of rubber trees, an area small enough to indicate that production could be multiplied many times, if the demand should arise. Many countries, however, lack the climatic conditions necessary for growing rubber trees, and in order to reach national self-sufficiency have sought substitutes. In the past few years success has been attained in such efforts through the production of various types of synthetic rubber. In some respects synthetic rubber is superior to natural rubber, for example, in being very resistant to the action of petroleum products. In Russia its manufacture has already become a national industry.

The enormous increase in the use of paper in recent years has been a major factor in the rapid cutting of the world's forests. Up to the present, conifers have been by far the largest source of wood for the manufacture of paper. Recently, however, more attention has been paid to hard woods, and methods have now been developed in the United States for the utilization of southern pine. Straw and other natural fibers are available in vast quantities and can be used if required; it is largely a question of economics.

In the light of what has already been said about the world's forests, it may be concluded that at the present rate of paper consumption the supply of raw materials can be maintained indefinitely. If the upward trend of consumption should continue, price increases sufficient to curtail present wasteful practices in the use of paper may be expected.

Comments and Conclusions

Thanks largely to science and technology, food supplies are likely to be adequate for a world population at least three or four times that of to-day, provided, of course, that the problem of distribution, with which this paper does not attempt to deal, can be solved. Although the future of some of the base metals is obscure, the world as a whole need fear no shortage for an indefinite period of the raw materials for clothing, shelter, heat, power and the principal necessities and luxuries of life. In the case of certain natural resources that are definitely exhaustible, nature has made abundant provision of possible substitutes.

All this is true of the world as a single economic unit. Unfortunately, however, the world is made up of a large number of economic units, many of which are endeavoring to establish economic self-sufficiency. For them the prospect is very different. Complete economic self-sufficiency is impossible, and even the measure of self-sufficiency for which many of the great powers of to-day are striving can be attained only by a major sacrifice of the standards of living.

In order to illustrate the extreme mutual dependence of the nations I have brought together in Table 6 some of the facts disclosed in our study to-night, and certain others which there has been no time to discuss. In this table the number "1" is taken to represent sub-

TABLE 6
NATIONAL SELF-SUFFICIENCY IN MAJOR MINERALS

	Br. Emp.	U.S.A.	U.S. S.R.	France and Dep.	Germany	Italy	Japan
Coal	1*	1	1	1	1	2	2
Iron	1	1	1	1	2	3	3
Copper	1	1	2	3	3	3	2
Lead	1	1	3	3	1	2	3
Zinc	1	1	2	2	2	3	2
Nickel	1	3	3	2	3	3	3
Tin	2	3	3	3	3	3	3
Asbestos	1	3	1	3	3	3	3
Petroleum	3	1	1	3	3	3	3

* Numerical order represents decreasing abundance in relation to national requirements.

stantially complete self-sufficiency, "2" partial or temporary self-sufficiency, and "3" definite lack of self-sufficiency.

From this it is evident that not a single one of the seven great powers is completely self-sufficient in supplies of the major minerals. The British Empire and the United States are, without question, in the happiest position in this respect. The U.S.S.R. is, I think, in a better relative position than that indicated by the table, since so large a part of her vast area is virtually unprospected. The other nations are very dependent upon international trade in minerals.

Nature has been generous in providing for man an abundant supply of the things he most needs, and will continue to provide for him, even though his wants be still further increased. Individual nations, on the other hand, are laboring under serious handicaps, largely self-imposed, and are suffering severely as a consequence. Let us hope they may eventually realize that the highest standards of living for their people can be attained only through international cooperation and world peace.

OBITUARY

EARL BALDWIN McKINLEY

THE disappearance of the Hawaii Clipper at sea on July 29 with its crew and passengers was a vital loss to medical education and medical research, for a passenger on this ship was a man who at the age of forty-three had risen to prominence and leadership in these fields. It was a great loss as well to various scientific societies in whose development this man had played a significant role. Every organization with which this leader came in contact felt the impact of his personality and was carried to higher levels of accomplishment. He was a man of the highest ideals, absolutely fearless in adhering to them. Original and ingenious in his ideas, he excelled in all these activities as well as in his research, to which he was devoted. Inspired by Novy and Vaughan while a medical student at the University of Michigan, his activity in research never faltered throughout all the administrative and organization work which engaged his attention. With apparently many years ahead of him for further outstanding accomplishments, it was a tragedy to have him disappear from our midst at such an early age; yet there is the satisfaction that Earl Baldwin McKinley was lost in the line of duty, seeking new knowledge, pioneering as was his wont.

Dr. McKinley was a passenger on the Clipper with Fred Campbell Meier, of the Department of Agriculture, for the purpose of making studies in aerobiology. These workers had become interested in the question of the transmission of various bacteria and pollens through the upper atmosphere over the high seas. McKinley also intended to continue his leprosy studies at Manila while awaiting the return of the Hawaii Clipper from its hop to China, and had made detailed arrangements for the skin testing of 500 lepers.

McKinley was born in Emporia, Kansas, on September 28, 1894, the son of Joseph Baldwin McKinley and Mary Elizabeth (Griffith). He left Emporia to enter the University of Michigan in 1912 and received his A.B. degree at that institution. His formal education was interrupted by the world war and soon after graduation he entered the service. Before leaving for overseas he married on June 23, 1917, Leola Edna Royce, a classmate of his at the University of Michigan. He served in the front-line trenches as an intelligence officer, and at the close of the war returned to this country, serving for a short time in the Medical Corps. In 1919 he re-entered the University of Michigan for his medical studies and became an assistant of Professor Novy. He accepted in 1922 the post of assistant professor in pathology and bacteriology in the College of Medicine of Baylor University. The next year he was made professor of hygiene and bacteriology and chairman of the department.

While at Baylor he continued his researches but, desiring further training, he resigned his professorship to become a fellow of the National Research Council and spent a year working under Jules Bordet at the Pasteur Institute of the University of Brussels. Upon his return to this country he accepted an assistant professorship of bacteriology at the College of Physicians and Surgeons, Columbia University. The following year he was made an associate professor, which post he held for only one year, resigning to become affiliated with the Rockefeller Foundation. During the year 1927–28 he served as field director of the International Health Board at Manila in the Philippines, and was a member of the Advisory Committee to the Governor General for the Control of Leprosy. At the completion of this work he again became a member of the staff