Man and the earth, by Nathaniel Southgate Shaler... a machine-readable transcription.

MAN AND THE EARTH I EARTH AND MAN

THE situation of man with reference to the material resources of the earth deserves more attention than has been given to it. Here and there students of the mineral deposits of certain countries, especially those of Great Britain, have computed the amounts of coal and iron within limited fields and estimated the probable time when those stores would be exhausted; but a general account of the tax that civilization makes on the fields it occupies and a forecast as to their endurance of the present and prospective demand on them is lacking. It is evident that such a fore-looking should be one of the first results of high culture. We may be sure those who look back upon us and our deeds from the centuries to come will remark upon the manner in which we use our heritage, and theirs, as we are now doing, in the spendthrift's way, with no care for those to come. They will date the end of barbarism from the time when the generations began to feel that they rightfully had no more than a life estate in this sphere, with no right to squander the inheritance of their kind.

To see our position with reference to the resources of the earth it is well to begin by nothing the fact that the lower animals, and primitive men as well, make no drain on its stores. They do not lessen the amount of soil or take from the minerals of the under-earth: in a small way they enrich it by their simple lives, for their forms are contributed to that store of chemically organized matter which serves the needs of those that come after them. With the first step upward, however, and ever in increasing measure as he mounts toward civilization, man becomes a spoiler. As soon as he attains the grade of a hunter he begins to disturb the balance of the life about him and in time he attains such success in the art that he exterminates the larger, and therefore the rarer, beasts. Thus when our *genus homo* comes into view, elephants of various species existed in considerable numbers in all the continents except Australia. Its first large accomplishment appears to have consisted in the extermination of these noble beasts in the Americas, in Europe, and in northern Asia. There is no historic record of this work, but the disappearance of the elephants can be well explained only by the supposition that they went down before the assault of vigorous men, as has been the case with many other species of large land animals.

So long as men remained in the estate of the hunter the damage they could do was limited to the destruction of the larger beasts and the birds, such as the moa, that could not fly. Prolific species, even of considerable size, such as the bisons, if they were nimble and combative, seem to have been able to hold the field against the attacks of primitive hunters. While in this station the tribes of men are never very numerous, for their wars, famines, and sorceries prevent their increase, which, under the most favorable conditions, is never rapid among savages. As soon, however, as stone implements begin to be replaced by those of metal, man begins to draw upon the limited stores of the under-earth, and with each advance in his arts the demand becomes the greater. In the first centuries of the iron age the requisition was much less than a pound each year for each person. Four

centuries ago it probably did not exceed, even in the most civilized countries, ten pounds per capita each year. It appears to have been at something like that rate when the English colonies were founded in North Amerca. At the present time, in the United States, it is at the average rate of about five hundred pounds per annum for every man, woman, and child in the land, and the demand is increasing with startling rapidity. It seems eminently probable that before the end of the present century, unless checked by a great advancement of cost, it will require a ton of iron each year to meet the progressive desires of this insatiable man.

Of the other long-used metals and other earth resources the increase in consumption is, with slight exceptions, as notable as in the case of iron; within a generation, mainly because of the use of the metal in electrical work, the need of copper has augmented even more rapidly than that of iron and the gain in the requirements is going on with exceeding speed. So, too, the demand for the other base metals long in use, zinc and tin, has been in nowise lessened by the more extended use of iron and copper; they are ever finding new places in the arts and a larger demand in the markets. As regards the so-called noble metals, silver and gold, the demand from the beginning has not been distinctly related to use, but to unlimited desire. Men have always wrested all they could of them from the earth or from each other, with little reference to the profit they won in the process. There has been of late something like a halt in the production of silver, except when it comes as a by-product, because it has generally been abandoned as a standard of value; but taken together the production of these precious metals has in modern times increased about as rapidly as that of iron. It is likely, however, that they will in time become of no economic importance.

As regards the earth's resources in the way of fuel--coal, oil, wood, petroleum, and peat--the history of the modern increase in demand is as evident and menacing as in the case of the metals. When the American English colonies were founded, coal had hardly begun to become into use in any country. It is doubtful if the output of the world amounted at that time to one hundred thousand tons, possibly to not more per capita of the folk in Europe than a pound, or about the same as iron at that late period in the so-called "iron age." At the present time the total production of Europe and North America amounts to an average of at least two tons per each unit of the population, and the increase goes on at a high ratio. Petroleum, practically unknown to the Occidental peoples until about half a century ago, has, with wonderful rapidity, become a necessity to all civilized and many barbaric peoples; the increase in the rate of consumption is swifter than that of any other earth product. Timber and peat, the primitive resources for light and heat, are the only earth products for which the demand has not greatly extended in modern times; it appears, indeed, to have shrunk in most civilized countries with the cheapening and diffusion of coal, due to the lessened cost of mining and of transportation.

The increase in the tax of the earth's resources is seen also in the very great number of substances which were unknown to the ancients, or disregarded by them, but which now find a large place in our arts. A comparison of the demands of three centuries ago with those of our day is interesting. In, say, 16000, when men were very much alive to the question of what they could gain, there were only about twenty substances, other than

precious stones, for which they looked the underground realm. Clays for the potter and bricklayer, whetstones and millstones, iron, copper, tin, gold, silver, lead, sand for glass, mica, coal, peat, salt, and mercury make up all the important elements of this list. At the present time, we more or less seriously depend on what is below the ground for several hundred substances or their immediate derivatives which find a place in our arts. Petroleum alone has afforded the basis of far more earth products than were in use at the time of the discovery of America. It gives us a large number of dyes and a host of medicines. It is indeed likely that the products immediately derived from the mineral oils exceed all those obtained from the earth at the time of Columbus--and each year brings additions to the demand.

The advance in needs of dynamic power, in modern times, has been even greater than in ponderable things. Even two centuries ago, the energy available for man's work was mainly limited to that obtained from domesticated animals. The wind served in a small measure through the sails of ships and of windmills, and there were water-wheels, but the average amount of energy at his service was certainly less than one horse-power per capita. At the present time it may safely be reckoned that in the United States and in European countries on a similar economic basis, the average amount is at least ten times as great, and the present rate of increase quite as high as in the case of mineral resources. It is true, that, so far as water is concerned, this increase in the demand for energy in the arts does not come as a tax on the store of the under-earth, as it is obtained through solar energy which would otherwise be dissipated in space. But the use of falling water as a source of power, though rapidly increasing, does not keep pace with that of coal, which is obtained from a store which is in process of rapid exhaustion, one that cannot be relied on for more than a few hundred years to come:--if the world keeps the rate of consumption with which it enters the twentieth century it will be exhausted before the twenty-third.

The problem of the underground store of wealth, though as we shall see on more detailed examination it is very serious, is not so immediate or menacing as that afforded by the question of food supply. As far as man is concerned, the supply has to come from two sources--the tilled soil and the waters, especially the sea. While it is possible by a widely extended system of fish culture greatly to increase the amount of food derived from the waters, experience does not warrant the supposition that the supply from this source can be manifolded. The life of the oceans, as of the primeval lands, is already packed to the utmost point. We cannot hope to double the number of edible fishes without reducing the number of their enemies or of the other creatures which compete with them for subsistence. Neither of these things can we at present see the way to do. It is to the soil, to the tilled soil alone, that we are to look for the body of the food that is to feed man for all the time he abides on this sphere.

In the life below man the relation of the creatures to the soil had been beautifully adjusted. The plants, by associated action, formed on all the land surfaces, except in very arid regions, a mat of roots and stems which served to defend the slowly decaying rock against the attack of the rain-water. This adjustment is so perfect that in a country bearing its primeval vegetation the eroding of the soil is essentially limited to what is brought about by the dissolving action of the water which creeps through the earth and there takes

the substances of the rocks into solution; very little goes away, in suspension, in the form of mud. In these conditions the slowly decaying rock passes very gradually to the sea; for a long time it bides in the soil layer where, with the advance in its decomposition, it affords the mineral substances needed by the plants that protect it. Thus until man disturbs the conditions of forest and prairie the soils tend to become deep and rich, affording the best possible sustenance to the plants which feed in them. In their normal state they represent the preserved waste of hundreds, or it may be, thousands of feet of rocks which have gradually worn down by being dissolved in the rain-water that creeps through them.

As soon as agriculture begins, the ancient order of the soils is subverted. In order to give his domesticated plants a chance to grow, the soil-tiller has to break up the ancient protective mantle of plants, which through ages of natural selection became adjusted to their task, and to expose the ground to the destructive action of the rain. How great this is may be judged by inspecting any newly ploughed field after a heavy rain. If the surface has been smoothed by the roller, we may note that where a potsherd or a flat pebble has protected the soil it rests on top of a little column of earth, the surrounding material having been washed away to the streams where it flows onward to the sea. A single heavy rainstorm may lower the surface of a tilled field to the amount of an inch, a greater waste than would, on the average, be brought about in natural conditions in four or five centuries. The result is that in any valley in which the soils are subjected to an ordinary destructive tillage the deportation of the material goes on far more rapidly than their restoration by the decay of the underlying rocks. Except for the alluvial plains whereupon the flood waters lay down the waste of fields of the upper country, nearly all parts of the arable lands which have been long subjected to the plough are thinned so that they retain only a part of their original food-yielding capacity. Moreover, the process of cropping takes away the soluble minerals more rapidly than they are prepared, so that there is a double waste in body and in the chemical materials needed by the food-giving plants.

There is no question that the wasting of soils under usual tillage conditions constitutes a very menacing evil. Whoever will go, with his eyes open to the matter, about the lands bordering on the Mediterranean, will see almost everywhere the result of this process. Besides the general pauperizing of the soils, he will find great areas where the fields have prevailingly steep slopes from which the rains have stripped away the coating down to the bed-rock. In Italy, Greece, and Spain, this damage has gone so far that the food-producing capacity of those countries has been greatly reduced since they were first subjected to general tillage. There is no basis for an accurate reckoning, but it seems likely from several local estimates that the average loss of tillage value of the region about the Mediterranean exceeds one-third of what it was originally. In sundry parts of the United States, especially in the hilly country of Virginia and Kentucky, the depth and fertility of the soil has in about one hundred and fifty years been shorn away in like great measure. Except in a few regions, as in England and Belgium, where the declivities are prevailingly gentle, it may be said that the tilled land of the world exhibits a steadfast reduction in those features which give it value to man. Even when the substance of the soil remains in unimpaired thickness, as in the so-called prairie lands of the Mississippi

valley, the progressive decrease on the average returns to cropping shows that the impoverishment is steadfastly going on.

In considering the struggle which men have to make in the time to come in order to maintain the food-giving value of the earth, it is well to keep in mind the fact that the battle is with one of the inevitables--with gravitation, which urges everything ponderable down into the sea. What we know as soil is rock material on its way to the deep, but considerably restrained in its going by the action of the plants which form a mat upon it. All the materials which go into solution naturally pass in that state on the same way; thus whatever we do, we cannot except to effect anything more than a retardation of the process to that point where the decay of the bed-rocks will effectively restrain the wasting process, so that the loss may be made good. It is indeed not desirable to arrest this passage of earth material to the sea. So far as that passage is here and there effected by natural processes we find that, in time, the soil loses its fertility because the necessary mineral constituents are exhausted. Thus in the case of the coal-beds, the swamp-bottoms in which the plants grew did not have their materials renewed by the decay of the underlying rock and so were in time exhausted by the drain upon them and became too unfertile to maintain vegetation. The preservation of the food-giving value of the soil as used by civilized man depends on the efficiency of the means by which he keeps the passage of the soil to the sea at a rate no greater than that at which it is restored by the decay of the materials on which it rests.

Some of those who have essayed a forecast of the future of man have felt that the prospect was shadowed by a doubt as to his permanence. Seeing, as we do, that the life of this earth is characteristically temporary, the species of any geological period rarely enduring to the next, it is a natural conclusion that our own kind will share the fate of others, and, in a geological sense of the word, soon pass away. Closer attention to the matter leads us to believe that the *genus homo* is one of those exceptional groups, of which there are many, which have a peculiar capacity for withstanding those influences which bring about the death of species. There are a number of such forms in most of the classes of animals, creatures which have existed, it may be, from palæozoic times, perhaps for fifty or more million years, so little changed that the earliest of them seem as nearly akin to the latest as are the diverse species of mankind. Man has been upon the earth certainly for two geological periods. He withstood the colossal accident of the last glacial epoch. He is by his intellectual quality exempted from most of the agents that destroy organic groups. So we may fairly reckon that he is not to pass from the earth in all foreseeable time, but is to master it and himself for ages of far-reaching endeavor. The limits set to him are not those set by the death of his species, but by the endurance of the earth to the demands his progressive desire make upon it.

We have already glanced at certain of these limitations in the future development of man in the extent of his present and increasing demands on the resources of the soil and the under-earth; before going further, let us consider what is the probable number of men that will have to be provided for, say, within three centuries to come--a future as remote as the past of our American history. At the present time the human population of the earth is somewhat variously estimated at from thirteen to sixteen hundred millions, for the reason

that the reckoning of the number in China and Africa is uncertain. It is most likely near the higher of those figures. The gain in three centuries has probably been at an average rate of near a million a year, and, at the present time, is very much greater. So far as we can see, this increase has been altogether among the peoples who have attained to the conditions of civilization, with the consequent partial exemption from pestilences and the evils of chronic war.

As the control of the modern conditions extends, either by the spontaneous development in the retarded peoples, as in China, or by the conqueror's hand, as in India and Egypt, we may reckon that the rate of this growth in population will increase. There is indeed danger that with Africa and China modernized, the rate will, by the end of the present century, be many times as great as it is at present. In a word, we may estimate that in a historic sense very soon the world will be near its food-producing limit. As to the numbers of our *genus* who will be demanding subsistence at the time when the ultimate of the earth's sustaining capacity is attained, no very precise determination can be made, yet a fair general idea of it may be had by considering the existing conditions in certain of the best known regions. Thus in Europe it is evident that an increase of one-half in the existing total cannot be accomplished without a great and practically inconceivable reduction in the standards of life of the people. The evidence of diminished birth-rate, as in France, leads to the conclusion that an unusual decrease in that rate will occur before there is any considerable abasement in the conditions of the folk.

In North America, the soils of the first order, those easily appropriated and affording large returns to tillage, have already been generally occupied. Further subjugation will have to be gained either from forested areas of the second and third class, where the soil will give relatively low returns to labor unless it is brought up to more than its natural fertility by a care which we are at present indisposed to give lean fields. Thus developed there are land reserves on this continent now in upland forests which may afford subsistence to twice or thrice the existing population. In this reckoning no account taken of the large unoccupied areas in northern Canada, which, it is claimed, are well suited for permanent tillage. There is yet doubt whether this district, owing to the limited range of the crops which can be grown in the very short summer, and the tax of the long-continued winters, will prove well fitted for the continuous uses of civilized man. Should they be found thus serviceable, we may add enough to the store of immediately available land to subsist from twenty to fifty million people.

In South America, the unoccupied lands which can be brought to use without engineering work appear to be sufficient extensive to maintain in the tropical and sub-tropical conditions of that continent a considerably greater population than can be supported by the soil of the North America. It is not unlikely that these tropical available lands could be made to support four or five hundred million folk at a standard of living quite as high as that now attained in India or China. By far the greater part of this population will dwell within the tropics, a region evidently unfitted for the development of what we esteem as the higher kind of man, but he will there have a fair share of the earth.

In Africa the conditions are very like those of South America. There is a very large area of tropical land which is scantily occupied by the peoples of the lower sort. These folk, however differ from the aboriginal peoples of the American continents in that they are fitted by nature for agricultural labor and can readily be made to work in an efficient way. Under the control of the masterful European states Africa is likely to afford room for a population of not less than five hundred million, of whom the greater part will necessarily be of the negro and Arab stocks, and this without reckoning the lands which may be won by engineering work from the deserts or the morasses.

In Australia and the islands of the Pacific realm, there is relatively little unused land which can be turned to account; in the humid tropical areas the population is generally well adjusted to the resources, and in the arid the opportunities from extended irrigation are not very great. It seems questionable whether room can be made in these lands for more than an additional fifty million folk.

There remains to be considered the great continent of Asia. In this ample realm, we find the population of all its fields south of Siberia in general pressed up against the limits of the soil resources. There is some room for gain in the region of the Twin Rivers and the Kahnates, but it is doubtful if without very extensive engineering work place can be made for another hundred million folk in the valleys which drain to the Pacific and the Indian oceans. The Arctic slope of the continent is the only field where there is an extensive unoccupied area which has conditions that promise to support a large additional population. The value of this district for the uses of civilized men cannot well be estimated with the information concerning which is now in hand: it is subjected to the same, or even more, doubt than that of the country of northern Canada. The greater part of it lies, like much of the land in sub-arctic Canada, in the region of permanently frozen sub-oil, only the upper foot or two sharing in the brief summer, so that the soil cannot be watered from below. That much of it is fertile and will for a time produce crops of small grain, roots, and forage is evident; but it is all afflicted with a long and very rigorous winter when water for man and beast has to be obtained by melting ice or snow, and the consumption of the stored food is very great. Moreover, there seems to be an insufficient supply of coal to serve even for domestic purposes, and in many parts of the country the resources from the natural timber are insufficient to meet such needs. Except where peat occurs, it is likely that the people will have to resort to the practice of burning the dung of their domesticated animals, and we know from the experience of western Russia how fatally and swiftly the fields are exhausted by this practice. Those only who are very optimistic will be disposed to reckon on an increase in the population of Siberia that will add one hundred million to the total of the Asiatic continent.

The foregoing glance at the conditions of the lands which are now open to the increase in population which has to be expected within two or three centuries may be taken approximately to show that, at most, there is enough to admit of something like a doubling of the present numbers; and that without any considerable engineering work in lands not now available for tillage a total of somewhere about four thousand million can be supported in tolerable comfort. The question arises as to the additional food-giving capacity of the earth which may be won by means of engineering and other scientific

work, as in irrigating arid fields or draining those which are excessively watered, or by improving the methods of fertilizing soils now in use.

It is impossible, with the present lack of information, to determine accurately how extensive is the field which may be won to tillage by the work of the engineers: this winning from the excessively arid lands will be done by irrigation, and from the morasses, the fresh-water swamps, and the marine marshes by drainage. In Europe the larger part of the land thus winnable has long been brought to use; it is not likely that an increase of ten per cent. in the food-giving capacity of its soils can, by any such means, be realized. In the less-developed continents the gain is likely to be much greater. Thus within the limits of the United States the writer has estimated that the fields improvable by drainage, in the manner already applied in Holland, would add to the tillable ground of the country an area somewhat exceeding one hundred thousand square miles in extent, with a food-giving value about four times that of the State of Illinois, wherein the soil would be far more enduring than that of any upland district. The complementary process, that of irrigation, promises to afford yet larger gains. Including the area of the South and the Middle West where the system would greatly increase the food-giving value of the soil we may reckon the possible enlargement from it would be even greater than that afforded by a complete drainage of the morasses. Taking the continent of North America as a whole, it seems probable that the existing capacity of its soils for feeding men may be doubled by the work of the engineer, through his skill in watering and unwatering its deserts and morasses.

On the other continents the opportunities for winning good land from arid deserts are probably less than in North America, yet the possible gain is such that we may reckon that when his great work is done, the engineer will have recovered land enough to feed the existing population of the earth. In Africa there is the magnificent problem of the Nile, a river which wastes to the sea in its annual floods water enough to fertilize tenfold the desert that it now makes fertile. There is the valley of the Twin Rivers of Asia, where a realm once fertile has become a waste by the loss of its irrigation works. There are in all the great lands vast areas of lakes, swamps, and marshes awaiting the skilful labor which has won Holland from the sea. The largest opportunity of profit is in such brave combats with the incomplete work of Nature.

The problem of how we are to maintain the fertility of the soil when the earth is taxed by a population price as great as it now supports, depends upon our ability to restrain the excessive rapidity with which tilled soils pass to the sea, and our ability to restore to the land the materials which the cultivated plants remove. We shall find that both these needs are fairly to be met by the resources of modern science; the first by a proper control of the movements of water from where it falls upon the land to its station in the ocean, and the second by a resort to the ocean and the under-earth for the materials to renew the fertility of the ground when it is exhausted by cropping. There is much to do in order to make the earth fit to bear the life to come, but there is every reason to believe that our science is ready for the task and that within two centuries of peaceful endeavor we may prepare the place for it. Some of the steps of this preparation will be considered in the following chapters of this book.

II THE FUTURE OF POWER

All the progressive desires which characterize modern civilization call for an ever-increasing share of the energy to be applied to the arts; from an economic point of view it is this feature which most clearly separates the culture of our time from that of the ancients. The Greek of the best estate had only the strength of a few domesticated animals and of slaves to help him to his large share in the world's goods. The pauper of our time is incidentally, but most effectively, helped by a retinue of mechanical servants, who give him the profit of perhaps a hundred fold as much energy as ever contributed to the welfare of an Athenian gentleman. This change has come about in very modern times, and is now in the prowess of its development; it is evidently to increase to the point when all the sources of power will be utilized to somewhere near their possible capacity, and the individual or the state of the century to come will have success in proportion to the dynamic energy that may be controlled. Therefore the first question in our effort to forecast the conditions of men concerns the possibilities of increasing the supply of power applicable to the arts.

A glance at the facts shows us that all the dynamic energy at the command of men comes more or less directly from the sun. To the idealist's advice, "Hitch your wagon to a star," the practical man might well retort that all our wagons are necessarily tackled to the particular star that does the work of this sphere. All that work, from the trifling share of brain and pen that writes these words to that which sways the winds and sends the waters in their streams, is celestial energy, practically all derived from the sun, energy which is held upon the earth by the air and set upon the diverse work we behold. We see this the more clearly upon the contrasted state of the moon, where for geologic ages there has been no work done because there is no air to entrap the heat and turn it to the varied tasks which it performs upon the earth.

The energy that is at work upon the surface of the earth, except the trifle from its depths derived mostly from volcanic outbreaks, comes immediately from the sun. The greater part of it is speedily sent forth again into the spaces. Only a little is for a time detained in the water that it has lifted into the air, or upon the lands, or mayhap for years in the bodies of animals and plants, or, exceptionally, for geologic ages, in the incompletely decayed remains of organic life which are buried in strata. The sources of energy available for mechanical power have to be from one or another of these stores derived from the sun. The most immediate of them, that which is the nearest to the source of power, is the wind; next in order the water, which has been lifted by solar heat to high levels on the land, and is on its gravitational journey back to the seas; then the waves of the sea, a possible, but in an economic sense improbable, source of power. Then again there is the timber of our forests, and, the last in this series, the buried organic remains, which give us access to ancient solar energy in the form of coal, mineral oils, and gases. Outside of this field of power derived from the sun, there is another source of some importance to be found in the tides, due mainly to the gravitative attraction of the moon, which promises in time to be locally serviceable to man. We shall now glance at these several resources with a view to estimating their prospective utility.

The largest share of solar energy which we have a chance to capture and turn to account in our arts is that embodied in the winds. There are as yet insufficient data for computing the quantity of this power that can possibly be won for our service, but it certainly amounts to very many times as much as is now won from all the other sources now utilized by man. This source of power was the first to be used-- at the outset in the sails of boats--but it has as yet afforded little help in the arts. The winds have ground much corn and pumped a deal of water, but, except in sails, they have not helped us much. The difficulty arises from the great variations in the speed of the air currents and the long periods in which the movement is so slight that they afford no effective power whatever, together with other periods when their speed is likely to be destructive to any machinery large enough to win much value in any state of their motion. It seems likely, however, that the method of the storage battery, with the cheapening of its cost and the increase of its efficiency, which may reasonably be expected in the near future, will enable us so to husband the energy afforded by windmills that they will serve for constant uses. It may also be possible to find a more direct way of utilizing this source of power by using the variable work of windmills in pumping water to a height whence it can be made to give a constant supply to water engines. As it is, this oldest servant of man is still among his useful helpers; the sails of mills and ships are together more numerous than any other machines by which he hitches his economic wagons to the stars, and in time they are likely to yield more power than all other devices.

The next largest source of solar energy is that obtained from falling water. Until less than a generation ago water-power had a very limited application, for the reason that it had to be utilized at or very near the point where it was obtained--and it could be carried by wire-rope belts for a distance of not more than a few hundred feet. With the method of turning the energy of falling water into electricity and hence back to dynamic power it is now possible to send that force a hundred miles from the point where it is obtained and with the improvements that are constantly making, it seems likely that the distance to which it may be conveyed will in time become practically unlimited. In no other case has the use of any source of power been so speedily extended. A glance at the rapidly developing situation will show us that this source of energy promises to effect very great changes in the seats of industries and consequently of population.

It is evident that the amount of water-power available in a country depends on three factors; the amount of rain, or melting snow; the average height above the sea of the field on which it falls; and the extent to which the flow of water is or can be evenly distributed throughout the year. This is a complex equation, one not easily solved, yet in a rough way it enables us to determine much as to the future of accessible power and thereby forecast the success of communities, so far as that success depends thereon. Thus in Europe we see that certain streams radiating from the Alps, such as the tributaries of the Rhone, the Po, and the Rhine, which are fed to a great extent by melting snows and have great natural reservoirs in the lakes through which they flow, are well placed in relation to this source of energy. So, too, with the streams of Sweden and Norway, which come down rapidly from a great height and are likewise, for various reasons, of fairly uniform discharge. Thus when coal becomes impossibly dear because of the approaching exhaustion of the limited store, as will be the case within three centuries, these favored

regions will be the seats of manufacturing, which will pass from its present stations where it depends on fuel.

On the whole North America is, as regards its possible water-powers, more favorably placed than any other continent. The amount of falling water is less than in South America, perhaps less than in Africa, but the distribution is better for the needs of man. In all the glaciated district which occupies near one-half of its surface, natural storage is provided by the porous water-holding nature of the drift deposits and by the lakes that by the tens of thousands occupy these glaciated fields. This glaciated district of North America is, indeed, the richest part of the world in streams fitted to drive wheels. We seek in vain elsewhere for any region of this kind comparable to the area on the eastern side of the continent between the Arctic circle and the Ohio and westward to the centre of the great continental valley, from the upper Mississippi and the Ohio to the Mackenzie River. The southern Appalachians also afford a field abounding in streams fitted to be sources of power, deficient only in storage, which is partly supplied by the forests and by the deep coating of decayed rock which, in a measure, acts, as does the drift, in the manner of a sponge to detain the water on its way to the sea. In the plain region of the Middle West, we have a broad field where the streams, because of their slight fall, can afford little help to man's arts. But again in the eastern face of the Cordilleras, from the Arkansas River northward to the Arctic circle, the rivers, though of scanty flow, promise great value in the way of power; and fed as they are by melting snows, their discharge, at least in their lower reaches, is fairly steadfast. In the central region of the Cordilleras there is as far north as the Canada line a wide belt of country where the rainfall is very small in amount. We find little power value in the streams, but on the western slope facing the Pacific Ocean, and increasingly from California northward to Alaska, there is, for its width, a noble body of power awaiting the call to use. It is this store combined with the mineral resources of the Cordilleran field, together with the quality of its people, that is to give the States of this region their dominance in the Pacific realm.

As to the water-power of the other continents, it may be said in general that while it is certain to be a vast advantage to many wide fields, it is rather narrowly limited in value by the lack of possibilities of storage, combined with a bad seasonal distribution. Of the regions which promise much, we may note the eastern face of the Andes for the greater part of its length, the high country of eastern Brazil, and, with some limitations, all the country from the La Plata northward; in Africa, certainly the valley of the upper Nile, that of the Zambesi, and, on a basis of imperfect knowledge, the great valleys of the Congo and of the Niger; as a whole this continent probably ranks next after North America in its water-power sources. In Australia the prevailing aridity of the region makes the value of this resource relatively small, yet in ratio to the food-yielding resources of the land it is considerable. The greater islands of the Malayan archipelago are, because of their prevailing high rainfall, fairly well placed for power. So, too, are the isles of the eastern coast of Asia; the Philippines are for narrow lands, fairly rich in opportunities for water mills; in Asia there is the promise to the future of its peoples of a vast profit from this source of help.

On the mainland of Asia the most important district for water-power is to be found in the southern versant of the Himalayas, where streams of fair volume and permanence descend from a great average height to the lower open country. This condition continues around the eastern side of the central Asiatic mountain systems, affording in the interior of China similar opportunities to those of India. On the Arctic slope of the continent the rivers, though of less flow than those discharging to the South and East, will afford a large amount of power. Below the headwaters in the Arctic slope of Siberia the rivers descend gently, and though of large volume, they are not likely to be of great value of the arts. As a whole, the share of available water-power in Asia, in proportion to its area or the food-giving capacity of its soils, is probably less than in any other of the continents except Australia. Yet even in Australia there is the promise of a vast profit from this source of help.

Considered as a whole, the rivers of the earth promise, with the aid of the engineer, to afford far more dynamic help to the arts than all that now serves them. Moreover, this help will be from sources of continuous supply and not like that from coal, in the way of speedy exhaustion. And further, the full utilization of the streams, as sources of power, because it involves the process of holding back the flood-waters, will in a considerable measure aid in diminishing the speed with which the soil passes to the sea, while the water, after it has been used to turn the wheels, may, to a great extent, be made to serve the purposes of irrigation. The increase in the use of this source of energy will probably not continue to be very rapid until the supply of the fossil fuel approaches exhaustion; from that time on it will necessarily be speedy, until all this group of resources is completely applied to the arts.

The other source of power originating beyond the earth is the tide produced mainly by the moon's attraction. This movement of the sea probably not exceeding in the central parts of the oceans a rise and fall of more than a foot or so, is in many places accumulated on the shores to a great height. There are many thousand miles of coast line where the average swing of the waters amounts to ten feet or more, and along hundreds of miles of shore it exceeds twice that amount. The total energy involved in the tidal movement is so large that if all of it could be turned to the uses of man there would be a supply ample for the needs of all the hosts which the soil could sustain with the best husbanding. Unfortunately, we can conceive of no convenient means whereby this power which the sun and moon expend upon the earth can in any great measure be applied to industries. The tide-mill, which appears to have been designed in England some centuries ago and to have been brought to this country on the colonial period, is a simple device consisting of a dam with wheels so arranged that they are impelled by the water as it enters or leaves the embayed space. The energy thus attained may be very considerable; it would not be costly at many places to win a maximum of several thousand horse-power. There is, however, the serious difficulty that the energy thus obtained is irregularly distributed, the maximum arising twice each day at mid-tide and falling to nothing four times each day at the time of low and high tide. There are yet other irregularities in the difference between spring and neap tides, as well as the daily alteration by about an hour of the maxima and minima of the risings. The result is that there have never been more than a few hundred tide-mills at any one time in operation, and these have been limited to such uses as

grinding corn. With the development of steam-power, they have gradually passed out of service, so that it is doubtful if there be a score of them now in operation in North America. It is, however, possible that with the development of an efficient storage-battery system the powers obtainable from the sides will be greatly increased. In the time, but a few centuries remote from the present, when the need of replacing the power derived from fuel is great, the side is pretty sure to afford a most valuable resource to all the countries about the northern parts of the Atlantic and Pacific oceans where the range is great and the sites for mills numerous.

It has often been suggested that power could be obtained from the motion of the sea waves. There is no question but that the energy involved in the surges is great, for in an ordinary storm the pressure of their stroke on the cliffs may amount to as much as ten thousand pounds to the square foot, or about that in an ordinary low-pressure boiler; but the exceedingly intermittent and variable nature of this action, together with the difficulties of maintaining any machinery which can render it serviceable for the arts, makes it unlikely that it will be utilized save in the last extremity of need.

There is yet another way by which we may find access to solar energy, one which is even more direct than any of those already described: we may reflect those rays by mirror or refract them by lenses and thereby concentrate their heat. There is an ancient story--surely no more than myth-- that Archimedes contrived to do this so effectively in the siege of Syracuse that he set fire to ships. In an extremity for lack of power there is no doubt that we could with some profit resort to this system. In those parts of the earth, in low latitudes, where the sky is rarely clouded, about a hundred square feet of mirrors would for some hours each day afford energy equal to a horse-power, but, as was just said, it would be a state of extreme and unforeseeable need that would bring this method into any considerable use.

This is true also of a project, once much discussed, of utilizing the central heat of the earth. It exists in such ample stores that if we could draw upon it, there would be power for all the conceivable needs of man for a million of years to come. But there is no conceivable way in which it could be brought to general use. Where there are hot springs of large volume it would be possible to turn them to service, but such opportunities are so exceptional as to be of no importance. It has also been suggested that it might be possible to bore down into the earth to a sufficient depth to heat water much above the boiling point; but, save near volcanic centres and certain other very exceptional places, this scheme is quite impracticable. The average increase in temperature is only about 100 deg. Fahr. for the mile of descent, and at less than three miles down the pressure would speedily close the pipe. Thus we see that the earth's vast inner store of energy cannot be of avail.

We come now to the energy derived from the sun, which can be won to use by burning the carbon which is locked up in organic matter; in the timber of the forests; in recent peats, or their equivalents; in beds of coal, and in those curious, carbonaceous products of animal remains, petroleum, and burnable rock gases. As for the wood of the forests, it is everywhere an ephemeral source of supply. When the earth is as fully peopled as it is

likely to be in the twenty-third century of our era, there will be no forests save those that may be preserved in order to insure the flow of streams. At best, and with the utmost economy, it requires about an acre of woodland to meet the needs of each civilized person in high latitudes--as much as is required for his food. With the crowding which now exists in most developed countries, this resource can have no value as a source of power.

The most recently formed of the fossil fuels, the peat deposits, which, in practically all cases, have been formed since the last glacial period, are of much more value as a source of power than is commonly reckoned. They occur in all the humid regions beyond the tropics; and, in general, are best developed in the glaciated districts. Data to determine their extent are lacking, but from certain observations in New England, it seems likely that the available widely scattered deposits of that district may be reckoned as having a total area of at least five hundred square miles, with an average depth of ten feet, the deposit having about the heat-giving value of ordinary coal contained in a bed of that area and rather less than half that thickness. Northward, on this continent, to the Arctic circle, the beds of this material are found in even larger proportion to the area. Probably the one-hundredth of the surface of the continent is similarly conditioned. The aggregate of this store is vast, amounting in volume to perhaps as much as all the coal beds, and in heat-giving value to perhaps one-half of those deposits. There are certain serious difficulties connected with the utilization of peat which have greatly limited its value in the arts and for a century or more have diminished its use as a fuel. When it is taken from the bogs it holds about half its weight of water, which is only slowly and partly dried away, and when the material is dried it is very bulky in proportion to its heat-giving power. A host of processes have been invented for drying and compressing the crude peat, but experience has shown that in the United States this cannot profitably be undertaken at the present price of coal. There is, however, the possibility that in many places the substance can be used without other treatment than drying for the manufacture of fuel gas, and this gas can then be burned for making electrical power. In such a way this store of ancient solar energy may become immediately available in the arts. In any event it remains a reserve on which the people of the future may draw in the ever-advancing need of power.

We turn now to the deeply buried deposits of carbon, coal, petroleum, and rock gas which have been the basis of the economic side of our modern civilization. It is well to begin this part of our inquiry by nothing that the formation of these stores of fuel depends on the action of organic creatures in taking carbon from the carbonic acid gas of the atmosphere and storing it in the earth. This task is effected by the plants, which each day take some million tons of carbon from the air to shape it in their forms. The greater part of this element goes back to the atmosphere on the death of the creatures it has served; some part of it is taken into the bodies of animals who are not able to obtain carbon directly from the inorganic realm. This, too, normally passes straightway back to the air by the processes of decay. In some part, however, the remains of plants and animals are deposited under water in such conditions that the carbon they hold is not quickly combined with oxygen and thus delivered into the air, but stays until it forms a bed of humus or peat and is buried in the sea bottom or in the beds of lakes beneath deposits of

clay, sand, or limestone; then, if it be the remains of plants, it may change to coal, and if it be animal waste, to petroleum or rock gas.

The passage from the state of peat to that of coal is gradual: with the escape of a certain part of the more volatile compounds of carbon in the form of gases and with the increasing pressure of the overlying rocks and the added heat, we have at first lignites; then brown coal; then in time bituminous; later, anthracite coal, and finally, at the extreme point of the series, graphite--an essentially unburnable form of carbon. In these changes of vegetable matter there is no considerable production of oil, and the gases which are formed do not seem to be preserved in the rocks. In the decomposition of the animal remains buried in strata there is no coaly substance produced, but if the conditions be favorable the free carbon of their bodies is combined with hydrogen, forming hydrocarbons in the form of the varied petroleum group and the commonest and most useful natural gas. This burial of carbon in the form of plant and animal remains in the burnable form suited to make coal, oil, or gas is exceptional; by far the greater part that enters the earth finds its way there in union with lime, magnesia, or other elements under conditions which do not admit of its being used as fuel. Probably of each ton of inhumed carbon so much as the hundredth part becomes a possible source of heat for the uses of man.

The amount of fossil fuel is not only small but evanescent. The beds of coal are always formed on the land; they have rarely been buried to the depth of more than a few thousand feet and are generally in process of rapid destruction by erosion. Oil and gas, being from the remains of marine animals, are usually found in rocks that obtain deeper burial and that occur more widely, but these substances are easily driven out by heat, and when the beds containing them are even moderately heated they are sent forth to the air. Moreover, the pressure of the gases on the rocks is constantly so great that they are always eager to escape from their prison, and are likely to expel the oil with which they are mingled. Thus it comes about that the fields of oil and gas are much more narrowly limited than those containing coal.

As a whole the combustible carbon in the forms of peat, coal, oil, and gas constitute the least important of the several great sources of energy which are at the command of man. They are not only exhaustible, but form a store that cannot be expected to endure the drain made on it for more than three or four centuries. We now know that the coal beds of any great value are essentially limited to the regions beyond the tropics, and practically to the regions north of 30 deg. north latitude. The reason for this is that the equatorial districts have always been the seat of such high temperature that peat, the first stage of coal, could not accumulate there to any considerable extent, and so the coal-making process did not have a chance to begin. The store is effectively limited to the northern parts of North America and of the Eurasian continent. Of this accumulation the share of Europe will be substantially exhausted by the end of the present century: indeed, if the present increase in the demands upon it continues, this exhaustion may come within sixty or seventy years. This does not mean that all or nearly all of the coal that lies beneath the surface will have been used, but that much of the store is now so deeply buried by the down-folding of strata that it is not in existing economic conditions available. That which

remains will serve only when the needs are desperate and are far beyond what can be met by the other sources of power and heat.

In northern Asia, especially in China, there are very extensive deposits of coal. The Chinese empire probably has a store larger than any other except that of the United States, a resource which, in combination with the cheap labor of that country, is certain to play a large part in the economic development of the lands about the northern Pacific realm. So far as the world is to depend on coal as a source of power, there are but two districts that will have a chance to attain a large and enduring success; these are the fields of western China and that of North America east of the Mississippi and south of the St. Lawrence, and these areas, vast as is the store of fuel they contain, are not likely to meet the demands made upon them in the next three hundred years. With rare and local exceptions their beds of coal are much more easily accessible because they require less deep mining than those of Europe or Asia, so that they will probably be exhausted long before those of England and Belgium come to an end.

The other burnable materials of the under-earth, rock, gas, and petroleum, will certainly not endure the demands made on them for nearly as long as will the coal deposits. The rock gases are a peculiarly evanescent store. Experience has shown that the fields which have been developed are not likely to afford a profitable supply for more than two or three decades. These fields are of seldom occurrence, none of considerable value having been found in Europe. The conditions of their formation indicate that they may not be expected to exist in the other continents to the extent that we find them in the central valley of North America. They are formed in vast quantities from the decomposition of organic matter, and in every coal bed in the transition period from peat to the bituminous a considerable part of the carbon combines with hydrogen to produce them; but for some reason that is not yet clear this gas is never in any considerable quantity retained in the coal-bearing strata. Now and then it is found in quantities great enough to originate those well-known unhappy explosions of mines which so frequently occur, but in these accidents the burning gas is small in quantity and of itself not the cause of the damage which is brought about by the fired coal dust that is shaken into the air. Now and then we may note the gas escaping from the newly broken face of the coal, showing that it is held, under pressure, in the mass; but, as above suggested, it passes from the strata to the upper air about as rapidly as it is formed. But when the rock gas is developed from animal remains near a bed of porous rock with a covering of dense material, the gas then finds lodgment in the interspaces and may gather a pressure of a thousand pounds or so to the square inch. When the beds containing the gas are penetrated by the drill, the discharge takes place so rapidly that a few years suffice to drain a large area. This source of energy is certain to be less enduring than any of the others to which man can turn.

The petroleums, when first brought into use, were supposed to afford a basis for industries as extensive and as lasting as the coal deposits. Time has shown that while these accumulations are in some places, as at Baku, in vast quantities, none of the so-called basins which are now drawn upon are likely to withstand the drain for a half-century to come. Inasmuch as the rock oils are formed from decomposing animal matter, there is reason to believe that they have been very generally produced in all marine

deposits abounding in fossils; that is, in nearly all beds formed on the floors of the ancient seas at some distance from the shores. It is tolerably certain that if we had access to all this oil, it would in amount many times exceed in energy-giving value all the other existing stores of fuel. Unfortunately, the rock gases are abundantly formed along with the oil; and by their accumulated pressure force the fluid to the surface, where it is broken up and dispersed. Consequently while there is probably a large amount of petroleum beneath the sea floors quite inaccessible to man; the amount at his disposal beneath the lands is small. In western Europe there is, in an economic sense, no petroleum. In North America, the fields probably now fairly well known are limited to the Mississippi valley and possibly the country to the northward as far as the Arctic circle, southern Texas, New Brunswick, and to a belt on the coast of California. The Baku, of Caspian district of Russia, is the only part of the old world where large amounts of oil are well known to exist, but it is likely that other fields will be disclosed in Siberia and in China. Like discoveries are to be reckoned on in Africa, Australia, and South America, but it is not at all likely that any of them will exceed North America in their yield, and it is evident that the oil of this continent will probably not outlast the present century.

It is to be noted that while the native petroleum of the world can be no more than a temporary source of energy in the forms of heat nd light, oil of like quality can be produced in vastly larger amounts from certain carbonaceous shales which plentifully occur in various part of the world. One of these formations, perhaps the most extensive, is that of the Ohio valley and adjacent districts in the east and north. Here we have a set of beds averaging more than a hundred feet in thickness which, over wide areas, will yield to distillation probably about one-tenth of its mass in oil, paraffin, and related substances; it affords the range of chemical properties which make our rock oils the source of so many substances necessary in the arts. From this deposit, but one of the many that are found in various parts of the world, we may look for a store of energy which may be drawn upon long after the beds of coal have been consumed. This oil and other burnable materials will be won at a much greater cost than where they are obtained from wells, in the fluid state; but the by-products of the distillation to which the rock is subjected will probably be as valuable as those afforded by the natural oil. The present writer has computed that the oil which may possibly be had from the Ohio shale above mentioned will in volume much exceed the amount of water contained in Lake Superior. This estimate cannot pretend to accuracy, but it may serve to indicate the amplitude of this source of material serving for a wide range of needs.

While the beds which may be distilled in order to obtain petroleum and its related products are very extensive and widely distributed, we cannot, with certainty, look to them as sources of power in most parts of the world, until the coal beds are effectively exhausted. As a source of illuminating oils they are likely to be resorted to extensively in the immediate future and to serve this use for centuries. It may be that the gas engine, that group of contrivances which seems likely to displace the engine of Watt, will be so developed that petroleum distilled from bituminous shales will be an economical source of power.

Viewed as a whole, the forecast for the future of power with the world peopled to its maximum of food-giving resources, is favorable. While coal and natural oils and gases are essentially temporary resources, not to be considered available for more than three or four centuries to come, they constitute but a small part of the offerings of nature on this sphere. The falling waters, the winds, and the tides are great and permanent sources of supply from which the crafty mind of man will be certain to win his needs for all his time. These sources of supply he will supplement with the oils obtained from the above-mentioned carbonaceous shales, and from the same source he will seek for dye-stuffs, medicaments, and the host of petroleum products which are now regarded as mere by-products. For all we dare reckon of the future the great stores of solar energy are sure to be at the service of our kind, as many as the earth can feed; and this in far larger share to each individual than we now demand.

X THE BEAUTY OF THE EARTH

Not the least important question as to the future of the earth when it has become completely domesticated concerns its expression to the eyes and mind of man, the beauty that it may then convey to beholders as it does to us in our time. There are those who feel that an intensely humanized earth, so arranged as to afford a living to the largest possible number of men, will lack much of the charm that it has now; that it will become so far artificial that its primitive nature will be utterly lost. A careful examination of the conditions will show us that while the order of beauty is doubtless to be greatly changed by the land of man, there is reason to believe that the alterations will enhance its æsthetic value, making its features far more contributive to spiritual enlargement than they were in their primal wilderness state. To discuss the reasons for his belief it will be necessary to set forth in the brief the naturalist's view as to the place of the aæsthetic motive in organic life, so that we may see how safely we may reckon on its development and control of man's conduct in the future.

It needs but a glance at the realm of animals and plants to make it plain that their qualities are largely shaped by influences that make for beauty. Their forms, colors, even their features of association that enter into landscape effects, are so ordered that they afford delight. In larger part these elements of beauty are due to natural actions, to the operation of forces that are absolutely beyond the control of the individual, and are hardly more to be termed organic than those that give rise to the shapeliness of crystals, to mountain outlines, or the order of the celestial spheres. In part, however, and this is a most important fact, this beauty is due to the deliberate intellectual choice of some one of the many animals that are engaged, even as we are, in an effort, however unconscious, to embody their conceptions of beauty in the objects they shape.

Although the extent to which the lower animals have by choice contributed to the beauty of the world is as yet, but little known, for the reason that the subject has only come into the field of enquiry within the last half-century, it is already clear that what they have effected is, in quantity, great, and in quality, of a very high order, measured in terms of our best human art. Thus the beauty of the flowers of all those plants which have colored and shapely corollas is unquestionably due to the choice of insects who are attracted to

them by those features which attract us. These blossoms are, in effect, like tavern signs set up to tempt the moth or bee to visit the plant, there to be regaled with the nectar or pollen, and by its visit to effect the process of fertilization in the desired way. In this manner, by this or that device of beauty in form, hue, or scent, the plant appeals to the insect's mind, to its sense of the æsthetic, and by the result gives us proof that even in this lowly state of mental development the desire for the beautiful; is kindred to out own.

In a very great number of insects, including representatives of nearly all the main groups of that class, as well as of the spiders and their kindred, the æsthetic motive of the creatures is well shown in the results of sexual selection, which leads to the evolution of such beauty as we find in the wings of the butterflies and months, the coloring of spiders, and a host of other ornamental features. Although this result arising from the selection of males on the basis of their beauty is much commingled with others due to protective mimicry, it remains clear enough to warrant us in believing that in many species of this class the sense of beauty, though of course quite unconscious to the possessor, is far stronger and more dominant than in mankind.

When we come to the vertebrates, we find in all the classes evidence that the motive of beauty is quite as manifest as in the lower realms of life. In them we find it shown, as in the lower life, both in the organic control that shapes the creatures to harmony, and in the individual choice of mates that leads to the selection of the most charming and, through that action, to the accumulation of beautiful features. Both these methods of attaining the common end are well exhibited in the fishes and the reptiles and, less distinctly, in the amphibians. When we come to the birds, the lineal successors of the reptilia, we find the quality of beauty more predominant and nearer to our own kindred emotions than in any other class of animals, even that in which we belong. Moreover, in the birds the beauty is to a greater extent the result of the selection which the female makes of its mate at the time of pairing. The result is that these creatures are, to us, the most beautiful of all organic shapes.

That the sense of beauty in the birds is not altogether limited to their sexual habits is fairly well shown by the fact that their nests often have a grace that seems to be attributable to a wider-ranging æsthetic motive, a measure of care beyond what is required for mere utility, or often given to them apparently to satisfy a desire for shapeliness. In one species, at least--the "bower bird"--the pair, or the members of a covey, decorate an assembly place with bits of bright-colored objects which apparently serve for ornament,for they cannot be for any other service. Add to these visible indications going to show a sense of beauty that derived from their songs, which, though perhaps not in a strict sense musical, are unquestionably charming, and we have a combination that clearly indicates a high development of the æsthetic sense.

It is an interesting fact that, as a group, the mammalia below man, and particularly in the series that leads toward him, manifest much less of the æsthetic motive than in any other great division of animals. In the sub-class of marsupials, the kindred of the opossum and the kangaroo, there is but little trace of sexual ornament, and that of insignificant æsthetic value. In the higher sub-class, that of the placentalia, to which we belong, we find that

some of the diversions from the main stem, such as the deer, antelopes, and the kindred of the cats, have by sexual selection acquired a certain measure of ornament in color and structure, such as antlers and banded or mottled hides, in no instance, however, comparable to the attainment of the birds. In the central part of the class, that which led toward man, sexual selection, as far as it has acted at all, has given shapes and colorings that are not beautiful, and in the apes may often fairly be classed as obscene. Of all the varied aspects of this group not one can be termed charming; they may, as a whole, be reckoned as the hideous of animals. Moreover, in all the nearer brute kindred of man we find no collateral indications of an æsthetic sense, no shapely structure, no sexual calls having any quality of song, unless possibly in the howling monkeys wherein, according to some observers, the notes of the cry run through an octave.

With an essentially unæsthetic ancestry, extending through thousands of species from the level of the amphibia, man comes to his life as man, as it would seem from the point of view of the æsthetic, the most hopeless creature on the planet. But here we find a marvel, perhaps the most wonderful of all the beset our passage from brute to man. As for all his other powers, his rationality, his sympathies, all else that goes to make his mind, we find that humanizing means no more than a swift and vast enlargement of the qualities that existed in the lower stages of his development. In the history of the æsthetic motive in man we come upon a sudden change in quality. The very lowest of his kind, the Andaman Islander and the lower African tribes, exhibit little, if any more sense of beauty than we find in the anthropoid apes. The evidence from these and other primitive tribes is to the effect that our genus did not begin with men who showed any kind of æsthetic spirit. On the contrary, their first steps in constructive work, their huts, weapons, clothing, and utensils are lacking in grace; they show that the sense of beauty had not yet awakened. As soon, however, as some skill in fashioning objects was attained, we note at once that the art motive is aroused. The original rude flint, no further shaped than would serve its clumsy purpose, is now fashioned with grace and with laborious patience dressed to graceful form; at once in a great diversity of races and tribes this motive of beauty swiftly enlarges until the men can do no manner of work that does not embody it.

This is not the place to consider the combination of impulses which inevitably lead all kinds of men, though in varying measure, to an awakening of the æsthetic sense--for it is a large and obscure problem. For our purpose, we need do no more than recognize the fact that the search for the beautiful is due to an instinct which naturally awakens in man as soon as he obtains command of the skill of hand sufficient to express his state of mind in fashioning things. We should also see that the results of this motive are in æsthetic quality essentially like those which owe their character to the minds of insects, as expressed in the beauty of flowers or the sexually selected ornament of the birds. In a word, the facts indicate that the sense and love of the beautiful is an essential quality of mind; that while it may long lie dormant, as it was in the mammalian ancestry of man, it remains unimpaired in its possibilities, ready to enter controllingly into action as soon as the chance is afforded. The main fact is to see how the world over, apparently among hundreds of tribal associations, this motive sprang up and at once took its place as the equal of any of those primal impulses which were inherited from the infra-human series all the way back to the beginnings of intellectual life.

Although the æsthetic motive in mankind when aroused was at once strong, it lacked the coherence and the certainty in its actions which we find in the lower life. Thus our art work is not so surely beautiful as that of the birds or the insects. Whole groups of men have for a time lapsed into mere fashion, or have lost their once well-developed æsthetic sense. Nevertheless the onward march of this impulse has been, on the whole, more continuous than is the case with any other of those developed within mankind. The alterations of the interest never seem to occur save where there is a breach in the conditions of its development, such as has taken place in the passage from household technics to systematic modern factory work. So long as it is a question of the solitary mind and the separate complete work the motive remains true. On the other hand, the extension of the impulse with the advance in human associations is remarkably great: beginning with the savage and his arms or his clay vessels, we find at each upward step in culture a widening of the field of art interest. At first it relates to personal affairs; it extends thence to the decoration of temples and of palaces, then to detached art in sculpture and painting. Finally, in the later stages of civilization, it begins to occupy the field of the landscape, first in forms of gardening closely united with architecture and sculpture, and finally with the landscape apart from all the accessories derived from other arts.

It needs but little enquiry into the history of the æsthetic perception of the landscape to show that while the motive was felt by many rather primitive peoples, it is the last of the fields of beauty to be widely opened to the appreciation of men. Among the Greeks there was a certain measure of sensitiveness to the charm of color and movement in the landscape, but little of that of form. A curious instance of this is to be found in the topography of Athens. On the north of the town, and fairly within it, there is the most interesting and beautiful hill in the Attic plain. This hill, Lycabetus, rises to about double the height of the acropolis, and is a far more picturesque object. It is, indeed, the leading feature in the scenery of the field, in a way controlling the whole view, yet it appears to have been quite unappreciated by the people who dwelt beside it, though their æsthetic perceptions in all save matters of the landscape were more highly developed than they have ever been in any land or time. So far as I can learn, there is but one mention of this mount in classic times, which if near any of our modern centres of culture would have found a large place in literature. There is no allusion to the surpassing beauty of the landscape visible from its summit, yet it must have been known to every one who dwelt in Athens.

The interest of the Romans in the beauty of nature was even as slight as that of the Greeks. We find with Virgil a sense of the charm in the humanized landscape, and now then, though seldom, a note of a wider appreciation that extends to some of the primitive aspects of the world; yet it is still with reference to men that it interests him and not for the pure nature of it. In the last of the poets of the classic period, in Rutilius Naumatianus, we find a touch of a spirit which is truly modern when then scene is valued for itself. After Rutilius there is a break of some eight centuries, when we come to the modern awakening, the so-called period of the new birth. From that time the growth in the appreciation of the landscape has been steadfast, though in greater part since the

seventeenth century. It has mainly affected the peoples of western Europe, though it is exhibited as well in the art of Japan.

The whole history of the landscape appreciation clearly shows that this extension of the æsthetic sense is the result of a natural process of development in which the spirit of man, at first intent on those things alone which immediately and personally concerned him, has, with the widening of his understanding, gone ever further afield until now it compasses the visible realm. We see that the sense of beauty is the companion of knowledge and that it is certain to keep its place in all the interests of man. We see, too, that it is naturally keenest in those fields where the will of man affects the expression. The absolute wilderness, however noble in its aspect, has æsthetic interest for relatively few persons. Even to them it lacks the charm of the fields that bear the impress of the hand of man. They need to be peopled in our sight or in our imagination, so that by sympathy we feel that we ourselves are commingled with it. Hence it is that only the more expanded souls can rejoice in the untrodden deserts, the pathless woods, or the mountains that have no trace of culture. Such people these places with their fancy--at least they feel the Lord is there: and so they have their bond with what else would be utterly strange to them.

The main point of this rather far-going yet insufficient account of the perception of landscape values is that the motive may safely be reckoned on in estimating the future of the care that is to be devoted to insuring the beauty of the earth. We see that the work of the landscape architect, effectively begun less than a century ago, is now advancing more rapidly than that of any other profession. At first it concerned gardens alone, the aim being to supplement the accomplishments of the architect by uniting his structures with the surrounding nature, so that there might be no jarring to the eye in the sudden passage from the artificial to the natural. Thence the duty of these artists has been extended to the care of parks and public reservations which, beginning with the commons of England, they play-grounds of rulers, and the spaces kept open for the defence of strongholds, have extended until every city has come to regard such holdings for the use of its people as necessary even as the streets and schools.

A concomitant of this development of the landscape architect's profession is the growth among all classes of men above the lowest of a sense of the beautiful in nature. A century ago travel, except for trade purposes, was limited to the very few--not one in a hundred journeyed to look upon the world. Now it is safe to say that practically all the folk who control our states regard their contemplation of natural beauty as one of the rewards of life. It does not matter that they, as yet, do not see with the trained eyes and mind attuned to the best; the vital point is that they have the hunger. As regards this art of the wide nature, they are in the state of the primitive man when he began to make his stone implements shapely: the work was, for at time, ill done, but it held the sure promise of noble growth.

We may now clearly discern that the landscape architect is no longer mainly to be concerned with beautifying patches of the earth with his clever contrivances of open spaces and vistas. His real part is hereafter to care for the beauty of wide realms. The

principle is well accepted that all the larger interests of man, those where the direction of affairs cannot safely be intrusted to individuals or corporations, shall be in the control of the commonwealth. Such matters as public health and education, navigable streams, road, and bridges, are now recognized as in the hands of the state. We are quite ready for the extension of this concept of duty to the field of æsthetic values, and we may confidently reckon that in the immediate future we shall have at least the beginnings of an effective care for those aspects of the earth which are of value to the spirit of man.

In forecasting the future of æsthetic values of the earth, we should take account of the fact that the oceans are unchangeable by the hand of man: they may lose their majestic loneliness as they become more peopled by ships, but here the wilderness quality will ever remain. So too with the strip of shoreland which they desolate. Save for the results of brutal misuse, which may readily be avoided, this debatable fringe of the land may retain its pristine quality. Of the continental expanses quite one-fourth of the area, so long as the earth's climate remains as it now is, will be unfit for tillage and only contributive to man's needs by its forests or its mines. Thus the arctic sixth part of North America, being fairly beyond the reach of Agriculture, must remain a wilderness save for the scanty population that its mineral wealth may support. The same is the case with its arid deserts of the Cordilleran field. For all that may be won from them by irrigation, they are to stay in their barrenness even as the seas. Add to such natural reservations the higher mountains, and we have even on this rather happy continent quite one-third of its area which is to retain its natural aspect, so that all men may for all time have a chance to behold the primal realm in its nobler shape.

On the other continents, the fields reserved by nature from the occupation of man are, on the average, quite as extensive as in North America. In Eurasia they form an even larger part of the land area, as is the case also in Australia, where probably not one-half of the surface will ever know any kind of tillage. In Africa not over two-thirds can be reckoned as of economic value. In South America alone is the proportion greater. In that continent the man-sustaining soils may be found to occupy four-fifths of the surface. It is thus evident that the first question in the future of the earth's natural beauty concerns the care that should be given to these inevitable wildernesses. On this point it is to be noted that the American government has, without formal design, made an extended experiment in this class of undertakings, an experiment which gives promise of being the type of such work. Beginning with the Yellowstone Park, the American government has in succession set aside a considerable part of the national domain to be preserved in its natural state, kept free from the depredations of hunters or the defacements of business. These holdings in the interest of mankind now include the most important part of the scenery of the Cordilleras, between Canada and Mexico, and we may be reasonably sure that these areas are effectively preserved for all foreseeable time.

It is interesting to note that the principle of keeping untouched the choicest parts of the American landscape has not only met the unquestioning approval of all of its people, but the system has fairly been adopted into the life of the folk. The inhabitants of the far West are not only eager to have new reservations made, and those already established well cared for, but those of the East are willing to tax themselves heavily to redeem from

private ownership the more important parts of their landscape that are in danger of defacement. We may fairly reckon that this motive, though as yet mainly limited to the United States, will become awakened in all civilized countries, in such measure that care will be taken to preserve the most valuable elements of the earth's natural beauty.

In estimating the needs of care for the safety of the beauty of the earth it is evident that there are two important groups of these features which are in imminent danger of irretrievable damage: these are the primeval forests and the streams with their waterfalls.

As for the forests, the reservations such as have been made in the Cordilleras abundantly provide for the preservation of sufficient samples. Though they will have to serve as sources of timber, and must thereby lose some of their pristine quality, they will retain their essential beauty as landscape features unharmed.

While the western protected areas are sufficient to ensure for the future samples of all the best of its woods, the Appalachian section of the continent is not thus guarded. The broad-leaved woods of the Ohio valley, those of the southern pine, the noblest of its group, and the northern species of white pine, which is at its best in New England, need immediate care lest they be utterly destroyed. There is no land in the East in government control, so that this warding will have to be done by purchase. It can effectively be brought about by two commonwealth parks of relatively small extent, one including the higher mountain district of North Carolina, with a small share of the lower valleys, in all about half a million acres, the other including the White Mountains of New Hampshire of about like area. These two reservations will cost about as much as two battleships, a trifle in the reckonings of the nation, but unlike the warships they will abide forever.

There is in this country yet another most desirable reservation--that of the Everglades of Florida, where there is a bit of nature the like of which is not found elsewhere, a field of unique beauty, that has not, as yet, and may never have, any value for the uses of civilized man. Not the least of its interest consists in the fact that it is the dwelling-place of the Seminole Indians, who escaped deportation beyond the Mississippi at the end of the wars in the first half of the nineteenth century. These people having been exempt from the control of the government, and practically so from contact with the whites, are the least changed of any aborigines in this country. A reservation here would not deprive our race of any notable economic values and would be a refuge for the most interesting remnant of the eastern tribes of American aborigines.

To do for the world at large what has so far been done in this country that we may assume its completion, will require a like system of deliberately chosen reservations on all continents. These cannot be at once reckoned either as to their fit place or their extent. It is, however, evident that they will have to be in something like the proportion that they are clearly to have in America, including in general between a fiftieth and a hundredth part of the surface yet not sacrificing any noteworthy part of the economic values of the earth. It may well be that from the timber they will afford they will, in an economic sense, justify their establishment.

Speculating on the possible position and extent of these reservations we see that they may well serve as harborages for many of the mammals and birds which else are sure of being swept away. Thus in Africa, in the region about the head-waters of the Nile, a reservation might well be established where a large part of the important mammalian species now near extinction could be preserved. There also, if the destructive process of civilizing the lower tribes of men could be avoided, we might hope to maintain sundry interesting varieties of our kind, now as certain to be destroyed as the giraffe or the African elephant. It may seem unreasonable to abandon an area of fifty thousand square miles, say as large as New York, to savagery, but if we consider the matter we will see that the primitive life of the world has its claim to existence quite as well as that of our civilizations.

Turning again to the question of preserving the beautiful aspects of the earth, we note that the streams and lakes are the most likely of all natural features to suffer from the action of man. In some ways this damage is unavoidable. The need of power, the most immediate and far-reaching of all man's necessities, is certain to destroy our waterfalls and rapids and to reduce all our rivers to a series of lake-like pools. This is their certain fate in a few generations from the present time, save when they enter the reservations where they are to be kept as samples of what they were when the earth was free. On the other hand, the lesser lakes are likely to retain much of their pristine beauty. Here and there they will be drained away that their bottoms may be tilled. In many instances they will be so controlled by dams as to retain the flood water of the rainy season to supply wheels in the dry season. This, by making a variable level, is somewhat harmful to the beauty of the shores, yet it will not be generally so.

If we would forecast the aspect of the lands when the earth is completely domesticated, we can do so in a fairly accurate way by visiting some of the cetres of the highest culture, such as are to be found in England, Holland, Egypt, or wherever men and wealth are most crowded: there we find beauty of a high order. It lacks, it is true, that quality of the primal which the wilderness alone can give, but in place of that single note of the deeps we have the great harmony of man's life. In the time to come this beauty of culture will be ordered as it is not now, so that the use of the earth may give harmonies with no discords. The

XI THE FUTURE OF NATURE UPON THE EARTH

THAT the title of this chapter may not be enigmatical, let us understand that by nature is meant the primitive species of animals and plants and their associations, the physical conditions which give the earth its expression; in fine, the assemblage of objects and actions that make up the wilderness when it is untouched by the hand of man. It is evident that all this is to undergo a great change by that same masterful hand of the supremely wilful creature whose progressive desires are likely to leave little, save with deliberate purpose, of the shapes that the ancient order established. We see, already, vast alterations since those desires began to expand. Half the land has lost its pristine aspect; many of the greater woods are gone to their remnants; hosts of animals have been destroyed, and other species once wide-ranging and dominant are reduced to scattered bands and are on the verge of extinction. The life of the world has learned of its new master in wide-spread

slaying and subjugation. The question is as to the measure of it that the awakening reason of the tyrant may leave.

First let us note that the organic species of the earth--animals and plants together, including the invisibly small as well as the visible--probably number between two and three million. We know as yet little concerning the microscopic forms, such as the bacteria, save when they are forced on our prying attention by their interference with our affairs. For all we know or are likely soon to learn, the number of these kinds may be as great as those of the other visible forms of life. It is by no means likely that our means of exploring the world of the small are or can be made sufficiently effective to reveal the least of these creatures.

Organic life does not consist, as some think, in a mere huddle of living objects contending with each other for a place in the world. It is rather a group of vast associations in which the species, each representing certain capacities and powers, are united as in a commonwealth. It is true that some prey upon others and most are competing with rivals for a chance to live, as is the case in our human societies; but for all the contention these great combined faunas and floras, these organic hosts of the earth, are effectively balanced organizations, the order of their relations having been determined by endless trials through the geological ages in which they have been developed.

We may see a little of this adjustment of species to species in an organic host when we consider the history of what we may term weeds, be they plant or animal. It is characteristic of all these excessively successful species that they are new-comers in the fields they infest, brought in from some other province where they are so adjusted to the species with which they have long been n contact that there they have no more than a fair chance to develop. In the region where they are weeds or pests they are not checked by their ancient rivals and enemies, species educated to contend with them, and so they run riot in their new-found freedom. This is the case not only with a host of plants, but many animals as well. The hares brought to Australia from Europe were in their native country kept in check by several carnivorous animals, foxes, weasels, etc., but the immigrants, not finding any effective enemies in their new country, became weeds--species with a measure of freedom none have in an adjusted assemblage of life. These weeds usually have their success in the tilled fields and not in the wildernesses; there they are apt to be beaten off by the well-organized forces of the natural life.

Now and then, in the natural order, there enters into these temporarily balanced organic hosts some species developed in its midst or introduced from some other field, a species which disturbs the original order. Usually, however, as above noted, the original occupants of the fauna and flora hold their ground so well that the solitary invaders have no chance to establish themselves: the changes are likely to occur not by haphazard immigration of species, but by the movement of the organic host as a whole under conditions of climatal or geographic change, which permit or compel assemblages to move this way or that over the surface of the land or the floor of the seas. The one exception to this general truth is in the case of man. He alone by his militant and

progressive desires has become the successful invader of all the organic provinces--the supremely successful weed.

In his primitive state before he became in any considerable extent a tool-maker, man appears to have been limited in his distribution, much as are the lower animals; but in proportion as he became endowed with fire, clothing, weapons, and other tools, his capacity to invade increased and his efficiency in destroying the inherited order of organic life rapidly augmented. We see the stage to which this has attained; we clearly foresee that it is as yet in its mere beginning, and that the original complexion of life is to remain only so far as man desires to leave it as nature made it. On the supposition that man is soon to begin to manage the life of the planet, not, as at present, in an accidental and generally destructive manner, but rationally and with a view to keeping and leaving it in a shape to be good for his successors, let us see what we can forecast as to the direction and results of his endeavors.

We may assume that the progress of man in the subjugation of the planet will eventually lead to the further disturbance of the ancient organic order. In fact these overturnings will be inevitable, as was the destruction of the North American bison, because most wild species of large size cannot maintain themselves save in large numbers and with a measure of freedom not possible where the land is to serve the needs of man. In part the destruction will be due to the fact that the creatures are on the natural way to extermination, as was the case with the dodo and the great auk, the hand of man giving no more than the last touch in the series of actions that brought the end. In some part the elimination of species will be due to the fact that the creatures are directly harmful to man. The tiger and its kindred among the mammals, sundry venomous serpents, and, perhaps, a few other vertebrates, will on this account have to be eliminated. Yet in this great group of back-boned animals there is certainly not one per cent. of the forms that by their habits warrant extermination.

In the life below the vertebrates we find the groups of animals and plants where the interests of mankind demand extensive destruction; yet there are only three of the many classes where such work is seriously called for. These are the bacteria, certain plasmodiums, and certain limited families of insects. The bacteria have a bad name, but of the vast host of their species there may be no more than a few score, possibly less, that harm man or his domesticated animals and plants. The greater number do work which from our point of view is beneficent, in some cases absolutely necessary for the maintenance of organic life. Of the plasmodiums we know that some forms are harmful, as they are the source of fevers. As a whole, these lowly organisms are to man by far the most inimical of all organisms: certainly more than half, probably more than three-fourths of the deaths in his species are due to their action; all the other agents of death save old age are of relatively trifling importance. His largest and most difficult task is to eradicate these mighty, though invisible, enemies.

From the Protozoa to the insects it is interesting to note that there is not a species which can be regarded as a serious enemy of man or of his domesticated animals. Some few, as the slugs, prey upon his gardens, the sea-nettles may sting him or, in the tropics, the land-

crabs may become a nuisance, and certain worms are the source of serious diseases, but from this great field of life he experiences at most but limited ills. When we come to the group of insects we find quite other conditions: there is a host of species which directly or indirectly bring us calamities. As is now well known, in the mosquitoes and the flies they transmit the bacteria and plasmodiums which produce malarial, typhoid, and yellow fever, and probably other maladies. The servants of man, the domesticated animals and plants, suffer even as much as their master from insect scourges; in fact, agriculture and herding have from the beginning had to war with these creatures which, by their adaptability to the conditions of other life, their marvellous energy and swift increase, are able to assail as no other creatures can.

The history of the ravages of the locusts in North Africa and elsewhere shows that it is possible for an insect profoundly to affect or even to exterminate a civilization. We are just now on the way of a momentous experiment of this nature in America. A species known as the Gypsy Moth, long and unhappily known as a pest in Europe, has recently been introduced in eastern Massachusetts. In its new environment, where the few enemies that in the old world contend against it are lacking, the species is spreading steadfastly and certainly. Where it is allowed freely to increase for a few years, it develops in such multitudes that it devours all kinds of vegetation, that of the forests as well as of the tilled ground. So far, in its spread it has come to occupy only a few hundred square miles of territory, and the efforts to supress it, though miserably irresolute, have served to restrain its depredations. There seems, however, to be a certain and very grave danger that when it becomes firmly implanted in the forests its assaults will be practicably irresistible. It is in the power of this creature, that a touch will slay, by its numbers to endanger our culture. This it will certainly do if its increase is not in some way arrested.

In general, we may trust to the arrest of the multiplication of any species of insect developing in its ancient associations with other life to the development of some inimical insect or some of the mould-breeding forms of life competent to destroy it. For a few years these plagues may increase after the manner of the army worm until their devastations are startling, then some ichneumon fly, which has the habit of laying its eggs in their grubs, avails itself of the extended opportunity and becomes in turn so plentiful that it destroys the host. But when, as in the case of the Gypsy Moth, the pest is an invader from another host and does not have to meet enemies trained for combat with it, the danger of its ravages is vastly enhanced. It is likely to be long before species competent to restrain them are brought to efficiency, and in the meantime the destruction goes on.

As before noted, the organic hosts are generally so well organized that their closed ranks usually defy the efforts of would-be invaders of their realm. It commonly requires the assistance of man, intentionally or unintentionally given, to effect the naturalization of a foreign form. Thus none of our weeds from the old world would have had a chance to obtain a foothold in this country, save for the fact that they have entered by the ways of commerce and have been first implanted on our cultivated fields. From that lodgment and nursery they can have a chance to spread to the less hospitable wildernesses. A good example of how this works in insects is again well illustrated by the history of the Gypsy

Moth in America. This insect has the habit of laying its eggs whenever it finds a chance to deposit them; where the creatures abound they are very often found on timber, furniture, casks, etc., so that it may be assumed as certain that for centuries they have been plentifully imported into this country. We have to believe that in thousands of instances these pests have hatched and the young had the chance to develop, but in no case did the species establish itself until in the latter part of the last century, when some of the kind were brought to eastern Massachusetts for purposes of experiment and reared in cages: by accident a considerable number of them in the grown state were released, and thereby the implantation was effected.

We see by the facts above noted that man's relation to the organic life about him will in part consist in two series of actions: in the suppression of the creatures noxious to him because of their assault on his health or comfort, and in the restriction of the wanderings of species which are kept in control in their native realms but become weeds when they are implanted elsewhere. Another part of his endeavors should go to the limitation of his destructive work within the narrowest possible bounds, so that the body of life of which he is to be the master shall suffer as little as may be from his control. That it is inevitably to suffer much from his innovations has to be accepted as the price to be paid for the humanization of the earth, a process which is but at its beginning and is to go on until the quality of the sphere is to be vastly changed. But the measure of the alteration and its essential results are for his determination, and their effect will be in large measure to determine his station.

It is evident that so far as the land-life is concerned the increase of numbers of mankind will inevitably break up many of the ancient organic hosts. The creatures of the sea, except those that afford food, are not likely to be disturbed, but with all the serviceable land occupied by the few plants and animals that are of use to civilization, and with the forests that remain after this selection devoted to the growth of those trees only that have value as timber, there will remain but the deserts and the untillable fields of high latitude where there will be a chance for nature to be maintained. Europe is already near to this state of complete subjugation: it seems pretty certain that in another century its wildernesses will all have disappeared. Not long after, the same conditions of utter domestication will come upon the fields of our own continent, and soon thereafter, even in the sense of human time, all the lands will be brought to the same state. It is, therefore, not too early to consider what losses this change will entail and what we of our time should do to minimize them.

First, we shall note that, manage the situation as best we may, this humanizing of the earth will necessarily entail a great loss of its organic species, for while only a few hundred, or at most a few thousand, kinds, need be sacrificed for the betterment of man's estate, a host will pass away because of the general disturbance which his civilized life brings about. It may be said that in the history of the earth the passing away of species is as common an event as the death of their individuals in our own times, and that human interference will but add a few score thousand to the hundreds of millions that have departed in their time. Yet we have to remember that this life of the earth is the record of the greatest work of the world and that, precious as it is to the science of to-day, it is to be

vastly more so to the science of the time to come. Each of these kinds we destroy is absolutely irreplaceable; no record we can make of it will be satisfactory to the learning of a thousand years hence. When a species dies it goes forever; for its like will never come into existence again. Moreover, we have to consider that, in the lame and impotent fragments of Nature that man is to leave, the processes that make new forms of wild land-life are in general to lapse, so that the places of those to be swept away are not likely to be filled. The question to which we are led by the points above noted is as to the groups of wild animals and plants which should be especially cared for, and the means by which they may most effectively be preserved.

While we cannot clearly foresee what animals will be most important to the science of future centuries, certain points of their interest we may fairly conjecture. We may presume that they will need to have types or examples of each group retained and, above all, those animals which belong to the more intelligent species: for the questions of mind in the lower creatures, interesting as they are to us, are to be far more so to our successors, who will be better able to approach the problems of psychology. We can see clearly enough that they have a right to demand from us the utmost care in preserving those forms that, even with our limited view, are clearly enough seen to be of singular psychologic value.

Leaving out of view the marine species where the advance of man is not likely to have much disturbing effect, and those in which we discern nothing of importance, we still find very many groups that demand protection. Among the invertebrates there are no species below the grade of the insects that are in danger of passing away because of man's action, but in that class there are sundry forms of remarkable mental quality that are likely to be exterminated before they have told their story to the students of the future. These are limited to those groups in which there are few kinds that need to be extirpated because of the damage they do. These groups are the ants, the bees, and the termites. In them we find the highest development of that form of mental action we term instinct. In the ants there are probably some hundreds of social species that show in a great variety of peculiar accomplishments the development of instincts. The same is the case in the groups of bees and wasps where the species, if less limited, are even richer in variety of mental actions. In these series of the hymenoptera there are few species in any measure harmful to man, while on the whole they afford the richest and most varied conditions of mentality existing in the invertebrates. The termites, commonly reckoned with the ants, but belonging to a very different order of insects, are a small and peculiarly interesting group: though occasionally harmful to man, they are not likely to be exterminated by him. As a whole, the insects most important to the psychologist are not likely to be exterminated or, if in danger of passing away, the passage will not come about for many centuries.

It is in the invertebrates above the level of the fishes that all the great losses arising from the domestication of the earth are to be expected. In the reptiles and batrachians, the lower classes of the type, the groups are already far advanced in their decline from the richness of their development in the middle age of organic history: there is little among them to preserve that seems specially important from the point of view of psychology.

They may well be left to their chance of survival, good for a long time to come, except in the case of the larger saurians, the kindred of the crocodiles, and the more venomous serpents. The humbler and harmless forms are pretty sure to keep their place beside man.

It is otherwise with the superior classes of the vertebrates, the mammals and the birds. In these groups the species are generally so active in their habits and so entangled in their environment that any considerable change in the conditions of their life is likely to lead, as it has in many instances led, to their speedy destruction. Among the birds it is probable that a dozen species have been extirpated by man within a thousand years, and many others are on the verge of extinction. Some of these were recently most abundant. Thus the passenger pigeon, which the present writer remembers only about half a century ago as the most numerous land-vertebrate of this or perhaps any other continent, is now a rare bird not readily to be found in any part of the field where it then super-abounded. Another instance from the same field is afforded by a species of parrot of the kind known as paroquets, which when Kentucky was first settled ranged as far north as the Ohio river. This interesting form has now been driven to the far South: the species is perhaps lost. In every part of the world the bird life appears to be far more disturbed by the advance of civilization than that of any other class. There are scores if not hundreds of species which are on the verge of extinction. It is indeed probable that, except for peculiar care, the most of those forms, which do not in a way adopt man and his works in the manner of the British sparrow, will be swept from the earth. This fate is particularly likely to overtake the migratory species, for in their wanderings they are exposed to a great variety of environing conditions, all of which are likely to be changed by the alterations that man is to make. It behooves us to take special care of these creatures, for they are in many ways the noblest products of life.

It is in the mammalia that we find the species which the students of the future will most desire to explore, for they are our nearest kindred and from them we learn the most as to the history of our own minds. Of the several thousand kinds of wild, suck-giving animals, none but a few score of the smaller sort, and some of the marine species which do not resort to the shores, will be safely housed when the earth is completely subjugated, save they be kept in selected wildernesses protected from the depredations of the monumental slayer. It is not too much to say that nearly all the larger forms already have been brought to the danger line, and that the greater number of them will, in one or two hundred years if they be not well cared for, utterly disappear. Within fifty years, several of the large mammals of Africa and America have been exterminated or brought so near to extinction that their end is certain.

It is not likely that any practicable measure of care will serve to protect the whole of our kindred mammalian species from death. The larger carnivora, the lion, tiger, etc., are too inconvenient to be spared. Certain of the herbivora, such as the African buffalo, are too ineradicably fierce to submit to the domestication of preserves. Of these unsavable forms there are not many; perhaps not more than a twentieth part of the whole number are beyond salvation. The remainder can be preserved, provided their master is willing to be a providence to them. Some of these, perhaps thirty species, need speedy care; the most can wait for a century or so before they are in imminent danger of extinction. On the

whole the herbivorous mammals of Africa are the most endangered of all their kindred. That continent, by far the richest in large species of the class, remained until the last century practically untrodden by the sportsman. The human assault on the life of this land was made for food, or, in the case of the elephant and the hippopotamus, for ivory, and with ineffective arms; now the land is the favorite range of that mighty beast, the big-game hunter, who, with tools vastly more effective than the native's spear or the flint-lock gun, kills not for profit but as a dog in a sheepfold for the mere love of killing. The African elephant, several of the antelopes of that country, and other very interesting species have been brought to the verge of extinction. In the opinion of those competent to judge, certain forms plentiful a hundred years ago have already passed away. The Indian elephant, because of his large place as a domesticated beast, although he does not breed freely in captivity, is apparently safe from extinction until supplanted by some kind of engine, but his African kinsman being much less domesticable, hardly fit, indeed, for the service of man, is doomed to certain and speedy extinction unless sedulously guarded from the sportsman; like most other large herbivora, it cannot maintain itself as a solitary paired form: it needs the conditions of the herd for its survival. As soon as it becomes rare it will speedily pass away.

On many accounts the elephants are likely to prove the most interesting of the lower mammalia to the psychologist of the centuries to come. They belong to a branch from the stem whence man came, that separated from that main stem at an early stage of its history and has departed further than almost any other of the herbivora. The most of these aberrant groups, such as the whales, the bats, the armadillos, etc., have low-grade mental powers, but the elephant, for reasons which cannot here be discussed, reasons still doubtful, are mentally the ablest and most human-like of all the brutes, with the possible exception of the anthropoid apes. Those apes have indeed the brutal qualities of man in startling perfection, but the elephants, at least those of the Asiatic group, share with us many of the better human attributes as do no other of the lower mammalian species. It is a most interesting question in the history of mind how these creatures came by their intellectual, and we may fairly add their moral, capacities. As the nearest of our spiritual kinsmen except the domesticated dogs, they demand our care; they should have it also for their scientific value. From this point of view the African species is needed for comparison with its diverse Asiatic kinsman.

From the point of view of the natural history of man, of which we yet know very little, it is particularly important that all those species which lie near the path through which he came from the lower life should be preserved for future enquiry. It is unhappily certain that there is no infra-human species or genus now existing through which we can trace our descent. Yet the gorilla is a near collateral, so near, indeed, that it may fairly be claimed that he is in the same family as man, or even that as animals are usually classified in the same sub-family or tribe. It is likely enough that he is as near to us in the genealogical tree as is the sheep to the goat, the lion to the tiger, or the bison to the buffalo. So, too, with all the creatures commonly termed apes; they lie about the place of the parent stem of our life, representing in a hundred or so living examples the marvellous history of that age-long up-climbing that brought, in the end, our kind. The greatest of all science problems is this of the coming of man; so far as we shall solve it

the work will have to be done from the study of the life nearest to the path on which he won his way. If these monuments be destroyed before they are surely interpreted the riddle may never be read.

It is always difficult to foresee the needs of the generations to come, and nowhere more so than in the field--we may indeed say the wide realm--of enquiry; yet it is safe to anticipate the needs of handing on to our successors all we can of our and their heritage of the earth as little impaired as we can contrive it to be. We may be sure that they will more readily pardon the waste we may make of its physical resources, its coal and ores, or even of the precious soil, than any unnecessary or avoidable destruction of its organic species. They will require these creatures not only for the advance of knowledge in general, but for much they have to learn concerning the safety and development of the mind and body of mankind. It is, for instance, evident that, in studies yet to be made as to the nature and modes of prevention of human diseases, many species of animals are to contribute largely to knowledge as to their nature as well as to the means of prevention. Two out of the limited number of our domesticated animals, by their physiological characteristics, now preserve us from two of the most fatal maladies. The cow has by the method of vaccination effectively relieved us to small-pox, and the horse is the only available creature for producing the antitoxin of diphtheria. Thus we see that, with the next beast swept away, there may go the possibilities of help to life as well as to learning.

In another chapter some of the ways in which we and our heritors may best deal with this difficult problem of making over the surface of the earth with the least possible destruction of its indigenous life will be noted. The arrangements to attain this end cannot be made at once, they must be gradually developed, as required by the advancing needs. What is, however, needed at once is a sense of the situation, a clearing away of the primitive childish notion that the marvellous life of this world is fitly to be taken as a toy for man, to be carelessly rent away with his plough, or slain for his diversion. The establishment of a truly civilized state of mind, as regards man's duty by those creatures of all degree who share life with him, is the necessary foundation for such conduct as will keep our race and time from shame in the age to come.

XII THE LAST OF EARTH AND MAN

In the previous chapters it has been more than once remarked that the earth is still in its youth and that the ages that it is to endure are likely to be as long as those which it has passed through since it came to bear its precious burthen of life. The evidence of this essential vigor is to be found in the fact that the two sources of energy, the sun and the underground depths, whence are derived all the processes of the sphere, are yet in the full tide of action and show no signs of exhaustion. Certain physicists, reckoning the sun's heat as due altogether to the falling in of its elements toward its gravitative centre and the consequent expulsion of its heat, have reckoned that the supply would be exhausted in from four to twenty million years. In this computation they have neglected to take into

account the fact that as the sun grows smaller it grows hotter, which would greatly prolong the heat out-giving process. Moreover the discovery that some elements are radio-active, giving out vast stores of energy acquired, we know not how, has made an end of all reckonings as to the origin or the endurance of the heat in the celestial spheres. If the sun has only a ten-thousandth part of its mass of radium, there is no limit to be assigned to its endurance as a vivifying centre of heat, by any computation we yet can make.

While the trifling part of the heat lost by the sun that falls upon the earth is the source of all its atmospheric movements and of organic life, that from its depths is necessary to keep the surface in the condition of mingled land and sea. The reason for this is simple, at least in its general nature. By losing heat the earth shrinks; as the loss of heat is from the depths, where a high temperature still exists, the shrinkage mainly takes place there and not to any considerable extent in the relatively cool outer parts of the sphere; hence this outer part of the sphere has to wrinkle in order to fit the lessened centre. This, though too briefly stated, is the cause of the upward wrinklings of the crust which form the continents, and of the downward that hold the sea. There are sundry other actions that come in to determine the mode in which this work is done, but the main point is that these movements are necessary in order to keep the dry land from being reduced to the level of the ocean. Should the earth's interior cease to lose heat, this uplifting process would come to an end, and the lands be worn down to the level of the waves. This would take time, for the average rate of the downwearing is somewhere about a foot in four thousand years; but it would be a matter of only a few geological periods before the continental areas would be brought to the condition of low, ill-drained plain lands, and a large part of their area would disappear beneath the sea.

What we know of the internal heat of the earth leads by lines of fact and argument, too long to be discussed in this writing, to the conclusion that the store of it is great enough by its loss to keep up the continent-building process for a vast period, probably for far longer than all the time which has elapsed since life came upon the earth. The amount of the loss is no great, being no more than would bring about a shortening of the earth's diameter by a foot or two in a thousand years. Yet this is enough to continue the upgrowth of the great lands at a rate sufficient to compensate for the down-wearing, as well as to maintain, in a way about to be described, the revolution of the earth on its axis, despite the fact that the tides produced by the moon and sun are ever and vigorously at work to arrest this movement. This curious tidal action has no large a place in the history of the celestial spheres, and so important a bearing on the future of the earth as a theater of life, that we should see it, so far as concerns our enquiry, as clearly as we can.

The general nature of tides, so far as those of the ocean go, is a matter of popular knowledge. We all know that the gravitative pull of the moon or sun on the earth is in accordance with Newton's law directly as the square of the distance of the matter that does the pulling; hence the water on the face towards the attracting body is lifted higher than that on the sides of earth, and that on the face opposite the attraction is less lifted than the mass of the sphere. So that there are two tides formed, one because the ocean is pulled away from the planet, and the other because the earth, as a whole, is drawn away

from the remoter waters. This is an over-simple explanation, but it is all that needed brevity will allow.

It has long been recognized that the earth in its daily rotation is ever swinging against the tidal waves, pushing them aside with its lands much as a ship breaks the wind-made waves. The result is necessarily somewhat to slow the turning movement of the sphere. The action is like that of a brake on a fly-wheel which continually diminishes the power that keeps it in motion. There is no means by which this energy of turning can effectively be replaced. It is a part of the original movement impressed on the earth at the time when the nebulous mass became separated from the other parts of the solar system; any subtraction, however small, necessarily slows and presently prevents the movement. When a man climbs a westwardsloping hill, he applies an infinitesimal amount of energy to accelerating the earth's movement; as he descends the eastern slope he does like immeasurably small work in speeding the machine. The tides are giants in this treadmill, and computation slows that in the course of a few thousand years they should mark their action by the shortening of the day by a second or two. But now come the astronomers, with fair proof drawn from evidence as to the time of occurrence of ancient eclipse, showing that the day cannot have shortened by as much as a second for all that tidal friction should have brought a vastly greater result about. The only discernible way out of this tangle is through the following considerations:

When a sphere is whirling with a certain fixed momentum, as in the case of the earth, as we lessen its diameter we increase the speed of the rotation. A familiar and fairly good instance of this may be had by swinging a weight attached by a string so that the cord winds around the finger; as the line shortens the turns are made in less and less time. Effectively the same principle is applied to the steam governor. We thus see that if the oceanic tides tend to diminish the rotation of the earth, as they surely do, then there is reason to believe that this action is neutralized by the shrinking of the sphere. This action of the oceanic tides is only a small part of the tidal work which has profoundly affected the celestial spheres and is continually acting, so long as they are not rigid to the gravitative pulls of other bodies. The wide-ranging effect of this action has recently been made known to us by George Darwin, and has, as yet, not entered into the field of popular science. It may, therefore, be worth while briefly to set it forth.

The effect of the tidal action of two spheres, while they are in the fluid or plastic state in which the tides can by their attraction cause the shapes of their masses to alter, is to send them further apart. Thus when the moon was set off from the earth, both spheres were, doubtless, much nearer to each other than they are at present. They may have been almost in contact, but at that time both of them had such a mobility of their particles that each produced great tides in the other. The effect of the interaction of these tidal protuberances was to push the bodies apart. The way in which the process is effected cannot be set forth, save in rather recondite mathematical form, or by complicated diagrams. Hence it may better go as a bald statement, with the assurance that the result is unquestionable.

So long as the earth and moon remained sufficiently fluid to allow their whole spheres to be tidalized, the constant, slight, but efficient strain, due to the action, pulled them away

from one another. When they become so far solidified that the tides ceased to deform their spheres. they ceased to work apart. The relatively slight uplifts of the oceans still have effect in this way, but it is so small that we cannot expect to trace it. In the case of nebulous masses which are passing into the state of solar systems where there are for a time fluid spheres, this sundering action of the tides has much to do with their shaping. This is particularly the case with those most puzzling wonders of the spaces, the double stars of the type when two neighboring suns revolve about their common centre of gravity. Because of the heat which their shining indicates, we have to believe that they are fluid enough to have vast tides which, in the manner above suggested, are driving them apart until they become separated, it may be, further than the most remote planet from the sun.

Coming back to the matter of the continuance of the earth in something like its present condition, we see that all the discernible facts point to the conclusion that, so far as the conditions of the ancient relations between the heat of the sun and of the earth's interior, the important elements in the mechanism, are concerned, there is no reason why a hundred million fair years of life may not be before this planet. As for the tidal effect, the earth has passed the time when the solar tides can push it further into space, for it is, as we know, too rigid to yield to that action except in the slight movement of the oceans. The question arises: Are there any other foreseeable accidents that may mar this fair prospect? There are certain of these which some pessimistic naturalists have looked forward to as possible and even probable sources of calamity. These we will now consider.

First of all, there are suggestions that the earth's atmosphere is in process of being deprived of the most important of its constituents, oxygen and carbon dioxide (CO_2), by the daily routine of its organic life. This is undoubtedly true as regards both of these substances. They are rapidly passing into the solid crust; each thousand years takes of them a notable amount from the air. In the case of the carbon, the vast withdrawal in forming limestones, coals, and coral beds is probably compensated in part by the emanations of its gas from volcanoes, and in part by the entrance of carbon meteorites into the atmosphere from the celestial spaces, where they are burned oxidized because of the high temperature the friction against the air brings about. In the case of the oxygen, the problem is not yet clear. We see no source whence the vast withdrawal due to the geologic processes can be made good. That it is in some way fed into the air, perhaps in the atomic state from the spaces, is made effectively certain by the following evidence:

We know that the atmosphere has not changed much in mass during the geologic periods from the Silurian to the present day, for since that time there has been no great alteration in the general character of the earth's climate. If the atmosphere were greatly increased in quantity, the effect would be proportionately to augment the temperature of the surface. A gain of one-tenth in the mass of the atmosphere so caused would probably change the heat at the sea level by not less than 50°Fahrenheit. Such an increase would, it is true, be resisted by the evaporation due to the gain in temperature, and the consequent development of a permanent cloud-wrap, impenetrable to the direct rays of the sun--a veil something like that which shrouds the planet Jupiter--but the effect would be to disturb

the admirable balance to which we owe the fitness of sea and land to nurture life. The fact that, since the Cambrian period, we have had the normal succession of glacial periods and those of no glaciation down to about the same parallels of latitude is fair proof that the mass of air has not been greater than it is at present. A like rain of reasoning leads us to believe that the mass of air has not been very much less than it now is since early geologic times. For if that mass had ever been reduced by as much as one-fourth, the result would have been a devastating cold, such as we encounter at the height of say twenty-five thousand feet above the sea level, where no living forms whatever can abide. In a word, the persistence of the air in vitalizing quantity seems to be well proved by the past of a hundred million years or more, so that we may reasonably assume that it is not likely to be disturbed for an indefinite time in the future.

As for the chemical constitution of the atmosphere, the evidence goes to show that it has been as constant as this mass. Experiments on a variety of animals and plants show that they do not tolerate any considerable variation in the quantity of the carbon dioxide or the oxygen it contains. A slight increase in the proportion of either of these substances held in the air is at once destructive to animals or plants alike. Nor can we fairly assume that in other ages these forms were more tolerant to the increase of these necessary materials. The fact seems clear that organic life began with an adjustment to the atmosphere substantially as it now exists, and throughout its history has found these conditions unchanged. Thus, so far as the mechanism of the earth itself is concerned, we may confidently reckon that the machinery is marvellously well fitted to keep on as it is for a vast time to come.

Turning now to the external dangers of the earth, let us see what chance there is of catastrophes due to events in the stiller spaces that might make an end of the ancient terrestrial order, or so far damage it as to make an end of its rational period--the reign of man. There is an interesting group of conjectures as to variations in the temperature of space which deserves brief mention. These are, in effect, that the stars in the heavens, the heat-radiating suns, are variously grouped so that there are realms of warmth where they abound, and other of cold where they are remote from each other. Now as our solar system is journeying at a speed of something like twenty miles a second toward the constellation of Hercules, may it not be that the earth will come to be in hotter and colder places during its voyage? The answer to this once much-discussed suggestion is that the share of heat given by the stars is presumably equal to the light they send, so that it would require that these radiant orbs should be very numerous and inconceivably near before they would materially affect the temperature of space. Moreover, though we are flying at stellar speed, it will require tens of millions of years to bring about any considerable change in our relation to the positions of other suns. Therefore, though this may be in a slight way a true cause of climatal change, it is too remote for us to reckon upon. It is safe to say that for the duration of man he will know skies like those of this time.

There is the old popular notion that a comet would in the end bring the finish to the earth; but now we know these bodies as trifling affairs: so far as danger is concerned not worth taking into account. It is doubtful if any of them are much more than clouds of scattered particles, shreds, it may be, of the ancient nebulous matter, from which solar systems are

made, which did not get embodied in the process of aggregation. Should one come in contact with the earth, an accident almost infinitely improbable, the effect would probably be a startling meteoric display and nothing more. There is, however, another group of bodies: the meteoric bodies composed in part of iron and in part of stony materials which give enough token of danger to warrant scrutiny. The facts about these materials are as follows:

Each year there are likely to be a number of meteoric falls, the masses varying in size from the smallest bits that can be identified to those weighing a ton or more. None of the greater masses have been seen on their way to the earth, but as these largest are of the iron group and, in most instances, easily discriminated from any earth materials by very evident features, there is no doubt that they are of celestial origin. So far as these bits that are known to have fallen on the earth are concerned, they are of no importance in its economy. Up to this day there is no well-attested instances in which they have in any way interfered with man. If we knew that we had learned the whole of the story we might well turn over the meteoric problem to those who are trying to solve the scientific aspects of it. There is, however, the chance that it may have import in relation to the future of the earth for the reason that, while as yet we have found none of these visitants of more than a few tons' weight, it is at first sight not inconceivable that one should collide with us of vastly greater size, say a mile in diameter. What will be the effect of such a contact?

We readily see that a meteoric mass weighing as much as a ton coming upon the earth at a speed of about twenty miles a second--perhaps twice that speed if the earth is swinging toward it--applies a vast amount of energy to the planet before it comes to rest. But by far the greater part of this is spent in rending its way through the thirty miles or so of air it traverses, so that when it strikes the ground it seems never to have the velocity of a modern cannon shot, as is shown by their slight penetration of the earth. If, on the other hand, the body was a mile or more in diameter the consequences would be very serious. Only a small part of the energy would be spent in the air, and the heat engendered in air and on earth as well as the shock would be sufficient to bring about the destruction of life over a wide area. The damage would increase with the diameter of the body in a high ratio, so that such a collision with a mass twenty miles in diameter would pretty surely be fatal to all the land-life of the earth.

Fortunately for our peace of mind, there seems good reason for believing that bodies of the group to which meteorites belong are not likely very much to exceed in size those we have found on the earth, and this for the reason that these bits have not been formed in the celestial spaces, but are evidently fragments cast forth from a sphere in the volcanic manner. This is proved by the fact that they are perfectly crystallized in a way that shows them to have been parts of a large mass. Their shapes indicate that the mass to which they belonged was subjected to strains that developed joints and faults. Their rent faces tell that they have passed from the parent body by explosive action. All these facts justify the hypothesis that they have been thrown out from volcanoes. Now all that we know of such explosions indicates that masses more than one or two thousand cubic feet in volume are not cast forth, the reason for this being that the violent action of the ejective process causes the rock to be broken into bits along its joint faces, or through the mass if joints be

lacking. We may, therefore, presume that so far as these falls of meteoric stones is concerned, there is little risk that we shall encounter any large enough to bring any damage to the earth.

Besides the meteorites, there is another group of bodies in our solar system from which there may be danger of collisions. These are the bodies, such as the asteroids, which inhabit the space between Mars and Jupiter, masses of relatively small size, apparently varying from a hundred to a thousand miles in diameter, and somewhat plentifully sown through a wide field. It is likely that they exist there by the thousand, and it is not improbable that very many of them are much smaller than those that have been detected. One body of this class, known as Vulcan, lies between our earth and Mars. It seems to be of rather irregular shape, and, what is more important, to be treading a very irregular orbit. As to the origin of these odd bits of matter, we are as yet in the darkness. They are too large to have been ejected by volcanic action, and seemingly too small to have run the normal course of a sphere from the primitive nebulous matter. It has been conjectured that they are the result of an explosion of a planet which hurled the mass into fragments, but their distribution in the field they occupy is against this view. Moreover, we cannot as yet conceive the action of any force that would so rend a sphere to bits. While the theory of the formation of these singular bodies is interesting enough, we are at the moment concerned with the question whether there may not be many of the same group too small to have been detected by the telescope which may, in course of time, collide with the earth.

As for likelihood of danger from stony planetoids or bolids colliding with the earth, we have two sets of evidence drawn from the physical history of the moon and earth. In the case of the moon, we have a sphere the surface of which is very ancient. There is reason to believe that it antedates the solidification of the earth's crust, and so, most likely, is some hundreds of millions years old. As the present writer has elsewhere noted, the visible part of the moon shows in the so-called seas what appears to be proof that there have been collisions with falling bodies large enough to melt the lunar rocks over ares some tens of thousands of miles in diameter. These collisions took place at a very ancient time after the greater part, but not all, of the heat of that sphere had passed from it. There is no basis for a reckoning as to the time of occurrence of these accidents, but for the reason that the moon, through a relatively small sphere, still retained, at the time of these accidents, as share of its heat, it is reasonable to suppose that the earth had not yet cooled down to the point when organic life was established upon it. This would establish the time of the lunar falls as at least a hundred million years ago, perhaps very much more remote.

The fall of large bodies on the moon, it if occurred, and the facts well warrant the supposition that it did, appears to have come about at or near the same time and, as we have noted, at a very remote period. If such then took place on the earth as a part of the same accident, it probably happened before our sphere had passed out of the universally molten state. Nothing that can be regarded as evidence of such a catastrophe has been found by geologists. If a record of it had been written on the solid globe, it would probably be evident to this day in a vast area of igneous rocks of a uniform nature such as

apparently exist in the so-called lunar seas. Moreover, the demonstrated continuity of life on all the continents from an early stage of the earth's development is proof that the delicate adjustment of its temperature has not been disturbed. The fall of a celestial mass sufficient to have formed the lava of the smallest "sea" on the moon would inevitably have disturbed the organic order in a way that would appear in the geological record.

Looking upon the problem of the earth's organic future in the light of its past, a method of enquiry by far the safest, for it involves no hypotheses whatever, we find great evidence that the conditions are such as to make a very long survival of the present conditions as certain as anything in this varied universe can be. We may assume that for a future, probably as long as the geologically recorded past, the sphere will go onward through time and space, free to work out its problems of life, with no break in the succession due to accidents coming from within or without. Here is a free field for much in the way of deeds. Whereto are they to lead and what is to be the end of it all? It is a great field of action and a fair one for speculations, though as yet but little explored.

The most important element in the future of man is the extent to which he may be able to obtain control of the processes of his own body, those which determine health, longevity, and, above all, his inheritances. In the chapter on the rational control of the earth the probabilities of such accomplishment are large possibilities of gain in all these regards. The question arises as to the directions in which the quality of life may be advanced through these accessions of capacity to shape it. In this field there is room for unlimited conjecture, but little to guide the process.

There are, however, certain features of this future which appear to be fairly determinable, and, though they are shadowy, not without interest to those who would forecast the future of mankind.

It is with a pleasure not without an alloy of regret that we may confidently look forward to men who are to look back on ourselves, as we to our ancestors of the bone and cave age--not despisingly, as we look upon those troglodytes, for the man to come will have too large a sense of relations for that--yet with a judgment that we were far back in the night when we thought we dwelt in the day. We may be sure that they will take us largely and tenderly, these folk of mayhap a million years hence, for they will feel the unity of life, while we merely discern it and that only in part. It is in this sense of the common bond of all life that those who are to look upon us from afar will have their greatest enlargement. Knowledge they will have beyond the conception of our time, as ours is beyond that of the lowest of our kind; but it is in the extension of the sympathies that our kind is to make its largest gains. By this our successors are at once to go far from us and to come nearer. In that field the gain may well be such as to make a new species, a new order of man, parted from us as we from the lower brutes, yet including our little lives in its vast extension.

There are many signs that show us the present wonderful expansion of the economic part of civilization which, by its magnitude of material achievements, hides from us the more important changes and gains that are taking place in the higher realm of the sympathies.

The first effect of this great modern movement was, in a measure, destructive to the emotional side of man that related to the so-called fine arts; we lost in part the ancient mode of expression of it through literature, sculpture, and painting. This loss seems to have been no more than the diversion of an ever-gathering stream into ways that led to an immediate rational sympathy with the fellow-man and the fellow-nature. In this field of action the only monuments are institutions and the states of mind they indicate. These show clearly that within the last four centuries, since we began to emerge from mediævalism, the gain in sympathy has, in the Aryan race, been greater than in all the previous stages of its advance. Other races, for obvious reasons, show less of this movement, but it is evidently a part of a series in which all the civilizable groups of men are to share, leading in the end to the completion of the evolution which began with the earliest organic form.

We may fairly expect this sympathetic development of men along with the rational within a brief geologic time to bring our genus to an intellectual and spiritual control of life such as we can but faintly divine with our imagination. There is no reason to forecast the end of this new order until the sun goes out, or the under-earth ceases to renew the theatre of life. That, so far as we can reckon, may well be as remote in the future as the dawn of life is in the past. We seem to be in the middle of the term with the most of the great doing, and with that in the spiritual realm yet to be done. When the end comes we may be sure that it will not be in the vile Schopenhauer way--by the voluntary abandonment by man of his life as a thing of evil--but by a cheerful surrender of it in the conviction that a great work is done, and that it is a fit part in an infinite accomplishment.

We may ask ourselves as to the last steps in the time when the earth and sun begin to wane in their activities and to verge slowly to the end. Will those far-off men elect to keep up the battle to the imperative finish, contending with the degradation that comes from shrunken lands or scant heat, or will they in their wisdom choose too pass out in their nobler state? To this we can give no other answer save that those enlarged semblances of ourselves will make their judgment from a high station and dutifully, as we should in our happier estate.

Man and the earth, by Nathaniel Southgate Shaler... a machine-readable transcription.

XIII THE ATTITUDE OF MAN TO THE EARTH-- SUMMARY AND CONCLUSIONS

THOSE who have read the preceding pages of this book must have perceived that so far as the matter they contain has other purpose than to be interesting, that purpose is meant to awaken a sense of the nobility and dignity of the relation man bears to this wonderful planet and the duty that comes therefrom. In this closing chapter I propose to assemble certain of these considerations in an effort to show the need of another than the old way of looking at the world about us as a mere toy or, at most, a useful mechanism, and to consider the obligations which it lays upon us.

There is a school of philosophers, like the most of such schools ancient and rather out of date, whose followers hold to the interesting notion that the universe is but an extension of the individual man: that all in the realm is but an enlargement of him who cognizes it--having its existence altogether from his appreciation. Like many another philosophy, this of the solipsists (i.e., *only himself-ists*), it is good to entertain its views at least for a time, because they serve, even if not strictly true, to enlarge our conceptions. As the naturalist sees it, this paradoxical statement of man's relation to the universe needs but a change of form to fit the facts better than any other theoretical interpretation. If we say that the universe is an extension of man because he has come forth from it and embodies in a way all in himself, we have a form of solipsism that suits the student of nature-- apparently the new mode of phrasing reverses the tenet--but it retains the essential point of the ingenious philosophy, for it acknowledges the identity of man and the realm in which he dwells.

There is good reason to believe that the main idea embodied in the philosophy which regards the world as essentially kin to ourselves is to be that held by the men of the hereafter. The whole trend of the understanding as to the relation of man to the realm leads to the conclusion that whatever else he may be, he is the sum of a series of actions linked with all that has gone on upon this earth. Already the more discerning see that our kind have come to the beginning of their mastery of this world by penetrating into its meanings, and further knowledge can only increase the clearness and sufficiency of this vision. We may assume that our successors will, generation by generation, be more and more inspired by this understanding: that they will come to see the world as a wider aspect of themselves.

If the above suggested view as to the trend of thought of men as to their relations with nature be true, then we have not long to wait until the care for the economical resources of the earth which has been advocated in the first chapters of this book, and for which people are already prepared, will be merged in a larger care for the sphere as a part of man from which he has been alienated by ignorance, but with which he is to be reconciled by knowledge. Seeing, as he must, for it is written on earth and sky, the oneness of Nature and intelligence as its master, man is sure to go forward unto the higher life of understanding out of which will come a sense, of which we see barely the traces in our time, of his duty by the earth. At present, the conception as to our place in the realm is so new, so confused with the ancient misunderstandings, that it is difficult to see how we can do the first part of our task by cooperating with the conditions which have made for the advance which has brought us to the gates of the new life. Certain directions for our endeavors are, however, plain.

To bring men to an appreciation of their station as masters of the earth it is necessary that they be effectively taught the nature of that relation. This is, indeed, the part of modern science, but we are as yet far from its accomplishment. So far as science is now passing to the body of the people, it is in the form of special, though elementary, knowledge of this or that group of the facts. Of such, men may have an endless amount and yet not be nearer to the understanding of the important truth; the need is to have this truth taught as a gospel. It has to go to men with the quality of religion, by the way of imagination and the emotions with which it is conjoined. There is reason to hope that we are at the

beginning of the process which is surely to require generations for its accomplishment. At best this enlargement will be slowly brought about and it cannot be expected immediately to affect the common folk. Unless the world of men should become philosophers, we must look in the future as in the past for the leading spirits, the rare men, to be guides to the new dispensation, the masses following in the ancient dumb way--taking their light not directly from nature, but in the good old way, mediately through their prophets.

Something may be done to hasten the growth of a better state of mind as to man's relation to nature by a much-needed change in our methods of teaching science. We now present the realm to beginners as a group of fragments labelled astronomy, geology, chemistry, physics, and biology, each, as set forth, appearing to him as a little world in itself, with its own separate life, having little to do with its neighbors. It is rare, indeed, in a very considerable experience with youths to find one who has gained any inkling as to the complete unity of nature. Seldom it is, even with those who attain mastery in some one of these learnings, that we find a true sense as to the absolute oneness of the realm, or the place of man as the highest product of its work. This is the inevitable position of those whose task it is to advance the frontiers of knowledge. The mass of their knowledge required to make way in any field is so great that little can be known of any other domain. But this situation of the investigator needs not be that of the ordinary man. Save for the merest trifle of knowledge which he gains by the simplest individual enquiries, he must take this nature on faith in his teachers. So far from trying to compass the learning of the smallest bit of the real, he needs be limited to the little of it that will best serve to enlarge his understandings of the world as a part of himself.

In the revision of our project concerning the share of natural science in our scheme of popular education--a revision long overdue and now sorely requiring action--we need begin by determining, first of all, what of its truths have cardinal value from the point of view of conduct; what of them, in a word, help to dutifulness by ennobling the conception of man's place in nature. Other matters may be taught for other purposes, for their purely intellectual values, or for their economic uses; but the great gain we are to have from the modern knowledge of the world is in the change of attitude it is to bring about: in the sense of kinship with the anciently alien realm and of duty by the great inheritance of life. To the making of this new spirit no great body of learning needs go; it will depend for its development far more on the way of approach than on the mass of the knowledge that is gained. So soon as men come to feel themselves as really the children of the world, the tides of affection that instinctively tend toward it, but have been sorely hindered by ancient misunderstandings, will help in the good work, and give us souls reconciled to their great house and eager to help its order.