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EUTOPOTROPISM:—SENSE TO FIND THE FIT PLACE[1]

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MY subject is Eu-topo-tropism. I imagine some of my profaner hearers will be inclined to say, "What in hell is eutopotropism?" To which I would reply, "It is not in hell."

Others more literary may ask, "In what dictionary is it?"

To which I would reply: "It is not in any dictionary. I made it up." I made it up to shock you so that you will remember the idea, for although the word is new, the idea is not.

Eutopotropism is the tendency or sense to know where you are well off and go there, the sense to find the fit place. It is the opposite of the trait exemplified by the June-bug who will "buzz and butt his head against a wall" or the moth that "shrivels in the fire."

I have an aim or a purpose, and my action is not determined by the past, but is determined by the future. I will call it by a word that you never heard before, that I invent for this occasion, eutopotropic. It means turning to the place where you are well off. The capacity to be eutopotropic is a sign of intelligence. For evolution by natural selection to work there must be three things —a variation, an environment where that variation fits, and, third, a disposition to occupy that environment. It is this third factor that I call eutopotropism. An extra coat of hair fitting an elephant to be a mammoth and live in the Northern part of Asia would not lead to a race of mammoths unless with the extra hair went a disposition toward a northern climate. It is this sense

[1] Address of the president of the Geological Society of America given at Tulsa, Oklahoma, December, 1931.

enough to know where you are well off and go there that I call eutopotropism.

Such behavior leads us to infer intelligence, whenever we can more easily infer actions from aims in the future than from causes in the past.[2]

The derivation is obvious to one familiar with English science or Greek roots. Heliotrope is the flower that turns toward the sun. At the Tropic of Cancer the sun turns backward in the heavens. The biologists have a string of terms ending in "tropic" and "tropism." A "tropism" is a turning, or an inherent tendency of a living organism to turn in response to an external stimulus.

J. Loeb, in his book on "Forced Movements, Tropisms and Animal Conduct," has a long list—of helio- geo- stereo- chemo- thermo- rheo- and anemo-tropisms —but he does not mention our eutopotropism, because he is not strong on intelligence, perhaps?

Eutopia I spell with an E to distinguish it from the Utopia of Sir Thomas More and other visionaries. His Utopia was supposed to be the land where everything was well, and as there is no such place, the name was derived from the two Greek words οὐ, not, and τόπος, place. The word τόπος, which we have also in the word "topography," is also a root in eutopotropism. But the first syllable is from the Greek εὐ, well, which we have in numerous other English words, as "eugenic," well-born, "euphonic," well-sounding.

Thus eutopotropism is the sense or tendency to turn to the place for which the organism is well fitted, to which it is preadapted. This place may be—indeed, it certainly will be—less fitted to other organisms. It is not a general Utopia, but it is a logical next step to the theory of preadaptation, as developed by Cuenot and Davenport, to consider for what the organism is preadapted and what it will do.

They pointed out that when an individual varies from its forebears, it will often do so in a way that makes it better fit and more able to survive in some particular set of surroundings before it is in them. If it comes to be in that particular set of surroundings, it and those similarly varying will there thrive. But will they have sense enough to go there or to stay if they find themselves there?

I use the term sense, because, ordinarily speaking, we regard behavior that takes you where you are well off and to the place for which you are fit as sensible, and the opposite tendency to kick against the pricks and to butt your head against a stone wall as unintelligent, or senseless. Perhaps others may prefer a longer word. Do not miss the idea, whatever you prefer.

I have chosen this subject as of interest not merely to us as geologists but to all of us as individuals and as members of the body politic. For we were men before we were geologists, and as we are composed of cells, in whose harmonious and fit cooperation is our bodily health, so we are but unit cells in that greater organism of society called the United States of America. It is well that we should find our fit place in it and that the whole nation should find its fit place in the family of nations.

But, granted that the subject is one of interest and importance, why is it fitting that I should select it on this occasion, which perhaps is the greatest opportunity of my lifetime to reach a wide, an intelligent and an influential audience. What has geology to do with it? Let me explain how I came to select it.

I trust you have not honored me with this high office simply because I have lived long enough to have arrived at years of discretion, nor because you think I will not bore you with too long an address and think that I have learned that brevity is the soul of wit, but because you also think that I have contributed somewhat to the science to which we are devoted.

If I had some great epoch-making geological discovery of my own to announce, it would be well to throw the limelight of this brilliant occasion upon it.

But Osler has suggested that new ideas do not come after sixty, and others have put the date as early as thirty. Failing such a discovery, it is natural to look over one's life and see which work of value seems to have been least appreciated.

I remember my old teacher Shaler at about this time of year, the time of the January mark-down sales, said to me: "Lane, I find at the end of the year I have a job lot of hypotheses that I would sell very cheap!"

So toward the end of life it is natural to look over ideas to see which have been sold and which, though still unsold, you consider valuable—not cheap, but such as you would commend to the attention of a discriminating audience.

Six years ago I coined the word eutopotropism in the heat of a verbal talk to students.[3] Thirty years ago I discussed the early surroundings of life and their evolution and the way life has adapted itself to the change,[4] and before that I had discussed the importance of individual choice in evolution.[5]

Indeed, I might go farther back. It is well-nigh forty years since I first addressed this society on the rôle of the earth's originally absorbed gases.[6] In some respects the conception of the rôle of the earth's

[2] "Some Contacts of Geology and Religion," *Harvard Alumni Bulletin*, Feb. 26, 1925.

[3] *Harvard Alumni Bulletin*, Feb. 26, 1925.

[4] SCIENCE, Aug. 2, 1907, p. 129.

[5] SCIENCE, May 4, 1906, p. 702, and *Outlook*, Vol. 58, p. 479, 1898, "Of Pegs and Holes, Individuality in Evolution."

[6] *Bul. Geol. Soc. Am.*, Vol. 5, pp. 259–280, 1894.

originally absorbed gases there defended doesn't need to be brought up again. It is sold!

That volcanic magmas contain gases and yield waters which do not come from the surface of the earth is now generally accepted, though as late as 1905[7] my old teacher Shaler said of outbreaks of volcanoes:

> This action appears to be due to the inclosure of water in the stratified rocks at the time when they are laid down on the sea floor; this crevice water becomes heated as the rocks become deeply buried, and by the central heat is brought to an exploding strain.

This possible source of some volcanic activity, illustrated in the frontispiece of Lyell's geology, is now almost entirely ignored. The works of Day, Allen, Fenner, Shepherd, Zies and their coworkers of the Geophysical Laboratory have thrown much light on the magmatic gases.

It is, however, a fair question on which we need more light which I commend to your consideration. What does become of the connate waters or petroleum when a sandstone is converted to a quartzite or a clay to a schist?[8] In the process of compaction, where and when and how do they go?

The rôle of magmatic gases and of juvenile waters is so well understood and so widely accepted now that I will bore you only for a few moments by recounting the evidence on one particular line of activity before I take up my main and more interesting theme, which is their effect on life.

These gases have a rôle in the crystallization of igneous rocks affecting not only the coarseness of grain of the igneous rocks and the minerals of the igneous rocks, which form from a rock magma as candy from syrup, but also affecting a wet and dry differentiation.[9] Hornblende and micas replace pyroxene and olivine, and the feldspar formation is prolonged as the magma gets wetter, with a consequent shifting of the eutectic or cotectic troughs and of the chemical character of the residual magmas available for differentiation. Much has been learned since 1895, and the recent president of the Association of Petroleum Geologists, Sidney Powers, has helped me to contribute thereto.[10]

Yet any treatment of rock crystallization and differentiation that would satisfy me and the severe and competent critics that would be in this audience would need mathematics and figures and diagrams, if it is to go beyond some such simple statement as above made, or a statement that the hotter the initial temperature of an igneous rock and its county rock are, and the more the mineralizers, the less pronounced will be the marginal belt of finer grain, while the general effect of the retention of these mineralizer gases is very much as though the temperature of crystallization was shifted toward that of the county rock and away from that of the original molten rock.

I remember that Professor Lindgren has complimented me as a "reformed mathematician." I must not backslide. So I put aside another subject. Geologic time, for instance, has much interested me and it would not be unseemly that, on the one and only occasion when a member of this society rises to the dignity of an American Senator and can take all the time to talk that he wants, he should take time for his subject. But I have recently spoken on time[11] and against time by radio. Dr. A. Holmes will treat it in his forthcoming Lowell lectures. Knopf's Bulletin 80 of the National Research Council has just given a masterly treatment. Finally, I do not think that I can handle the forty odd methods of estimating geologic time that I have listed, in a fashion to suit me without many figures, some mathematics and several hours! Gladstone, they say, could make a budget interesting, but I am no Gladstone, and I put it aside.

Before we discuss the way life has been affected by and has met the changes produced by the progressive inorganic evolution which these escaping gases have caused, let us first consider what signs there are of such an evolution and reasons for believing in it.

Returning to this exudation of gases from the interior, I would ask: If there has been a continuous supply of gases from within added to the ocean of air and of water and also a precipitation from the ocean either directly or by deposits due to organic life, would it not be a very striking and remarkable balance if there had not been some change in the oceans of air and water and an inorganic evolution in the sediments formed in them as well?

The more active of these gases will be combined and largely precipitated. For instance, the carbon dioxide so common in volcanic gases will be the food of plants, and the chlorine and sulphate will combine with bases.

But the more inert nitrogen and the rare gases will accumulate. Therefore, we are not surprised to find that they form a large part of our atmosphere.

If we find signs of glaciation and a more rigorous climate in early times, one factor may be that there was less atmosphere then. A rise of 300 feet in the atmosphere means a drop in average temperature of something like a degree. Thus the climate in times past must have varied with the amount of atmosphere. Taking away three thousand feet of atmosphere might well bring on another ice age if it meant

7 Shaler, "Man and the Earth," p. 170–171.

8 *Bul. Geol. Soc. Am.*, Vol. 24, p. 704, 1913.

9 "Wet and Dry Differentiation," Tufts College Studies, Vol. iii, No. 1, 1910, pp. 39–53.

10 *Bul. A. I. M. E.*, No. 110, 1916, pp. 535–548.

11 *Scientific American*, Feb., 1930; *Scientific Monthly*, Apr., 1931.

lowering the snow-line 3,000 feet. This may have counterbalanced any possible greater heat on the sun. The diameter of the sun was very likely greater and that would tend to equalize the temperature at different latitudes. The brightness or amount of heat would tend to equalize the temperature at different latitudes. The brightness or amount of heat per unit of its area is likely also to have varied. Possibly for the former reason, but very likely more from a different distribution of land and water, climatic zones seem not to have been as marked in the remote past as at present.

If the crust of the earth was ever hot enough to vaporize all the water in the ocean and the ocean was anything like its present ocean, the temperature at the base of this very heavy atmosphere might be far above 100° C. and near the critical temperature of water, 374°. The water would remain gas until cooled down to that temperature. Thereafter from that point the rock surface temperature would slowly drop, a process ignored by Lord Kelvin.

I do not, however, personally believe that the early ocean, either of water or air, had the volume of the present. If Foqué was right in estimating that one of Etna's minor parasitic cones emitted in 100 days 2,100,000 cubic meters of water, in 600 years it would discharge a cubic mile. Thus only a hundred such vents would suffice to discharge all the 300 million cubic miles of sea water in the 1,800 million years or so in which it seems likely we have had plenty of time to have discharged the ocean.

Of volcanic gases the vast bulk is water.[12] Some of the water gas might be absorbed in hydration of the rocks. But the crust of the earth, ever near enough to the surface to be hydrated, must be much less than 10 km[13] and much less than 5 per cent. by weight of the 10 km can be water. This would be about 2 per cent. by volume, so that the water absorbed in the crust must be less than 200 meters, no great addition to the volume in the ocean.[14] Most of the water exuded from the interior must be still in the ocean, whose volume is continually increased by volcanic emanations. I know no signs that the earth is absorbing the oceans or that they were once deeper than now—quite the contrary.

The next most abundant gas is carbon dioxide. This can be and is precipitated directly as calcium magnesium, ferrous and other carbonates. As soon as plants were available, it would be decomposed by them into vegetable fiber and oxygen.

To be sure, vegetable fiber may be eaten and oxygen breathed by animals and reunited. Yet insofar as we find carbonaceous matter of organic origin in the crust of the earth, petroleum, coal, peat, natural gas, etc., we may reasonably look for the oxygen which went with it, when the carbonaceous matter was reduced by plants from CO_2. Some of it goes into oxidation of the red rocks, as C. H. Smyth[15] has estimated. But this will not account for all. For the balance we may look to the amount of oxygen in the air, some four pounds per square inch, though, as we really know nothing as to how much carbon there is beneath the three quarters of the earth's crust covered by the oceans, an estimate might well be characterized as three hops of hypothesis, a skip of computation and a jump to a conclusion!

Nitrogen of the volcanic gases must also accumulate, mainly in the atmosphere, for the amount in the rocks and waters is much less than the carbon dioxide. Here again it may be possible to compute whether the nitrogen in the air is to the water of the ocean and the oxygen of the air as the analyses of volcanic gases would lead us to expect. The sulphur may be represented in the sulphates of the ocean, the anhydrite and gypsum of the land and in the widespread sulphides. The chlorine is partly represented in the salt domes and the salt water of the strata and the chlorine of the ocean. When first delivered, whether as HCl or Cl, it would naturally attack the bases in the order of their abundance and ease of attack. Calcium and iron chloride would be more abundant than sodium chlorides. But when it comes to precipitation, calcium, magnesium and iron are surely deposited from the ocean more than the sodium. It will be a rare drilled well in which there is not more lime than soda in the cuttings. Therefore, there will accumulate in the ocean an increasing proportion of sodium, while in the early ocean there was a relatively larger proportion of earthy chlorides.

While we can not say offhand that the ocean would be growing saltier, since that would depend on the relative supply of water or base exchanges, the precipitation effect of organisms and other factors, it seems almost certain that there has been an increase in the proportions of sodium to chlorine. Moreover, all lakes without outlets tend to grow saltier. Why should that great salt lake called the ocean be an exception? The very old and very salt waters that are sometimes encountered one would have to explain as the residue after the hydration of volcanic glass and the formation of chlorite.[16]

But all this is a deduction from the general idea of exudations from the interior. Are there any facts

[12] *Shepherd Bul.* Hawaiian Volcano Obs., viii, 5, 1920, p. 2, other papers of this observatory and various papers of the Geophysical Laboratory.

[13] Clarke, "Data of Geochemistry," *U. S. G. S. Bulletin*, 770, pp. 32, 34.

[14] M. L. Fuller and others cited in Clarke, *ibid.*, p. 35, make it perhaps 1 per cent. of the ocean.

[15] *Jour. Geol.*, 13, 1905, pp. 319–332.

[16] *Bul. A. A. Pet. Geol.* 11, 1927, p. 1283–1305.

to substantiate this idea? I think that critical study of analyses of waters, and other facts support it.

The question how we can distinguish between the waters circulating down into the rocks now or from past land surfaces, the connate waters originally laid down in the rocks, and these juvenile waters which have emanated from below from invasions of igneous magmas—has been on my mind. It might well be the subject of a course of lectures. But it involves a detailed consideration of analyses of the waters. Many of you perhaps, like myself, can not very well understand figures by hearing them. I have to see them to understand. Perhaps some of you hate figures, anyway. Moreover, there are men here who have vastly more material at their disposal than I, who will take it up and by careful study of water analyses will be able to distinguish buried land surfaces which have been leached and filled with a water quite different from that which originally filled the beds. So I shall not go into the matter in detail on this occasion, though I should be glad to take it up with them individually. I look to a time when, with wide-spread use of accurate analytic methods, we shall find the rarer ingredients also significant, iodine perhaps rarer in the older rock. We might, in the age of the surrounding strata, find a reason for the low iodine and prevalence of goiter around Lake Superior. The distribution of Sr may also be significant, and the concomitant gashed dolomites.

I expect to see old land surfaces and disconformities recognized by the associated waters. I suspect that, as in the Red Coulée field of Canada,[17] they will be marked by a lower concentration and an increase in other acid ions relative to chlorine, and in sodium as well. Perhaps also, as R. L. Ginter suggests, organisms coming in from these old land surfaces may be traced by their biochemical reactions.

Again, while I do not propose to bore you with detailed discussion, are there not signs that in the earliest rocks, the Keewatin, or "greenstone schists," as they used fitly to be called, we have a formation which does differ significantly from the later rocks? There are less signs of contemporary oxidation. The abundant lava flows lack the reddened top of later lavas. Sedimentary carbonaceous beds are rare or absent. So seem to be red beds of any kind and red gangue or flucan, or hematites that might be considered laterites.

We do not find beds of salt or gypsum or metamorphic equivalents of these in the Precambrian. I think the ferrous carbonates are more common in the Precambrian, which would be natural if this early atmosphere was not so oxidizing.

In this early period when there was little or no oxygen in the air, air-breathing animal life would be relatively absent. If we may carry over into geology the distinction made in college catalogues between biology and zoology, we might say that there was an early Azoic but not Abiotic Era. In the early Precambrian Keewatin rocks signs of animal life, at any rate, are rare.

I am convinced that the Precambrian limestones are akin to the so-called "shell marls" which my lamented friend, Charles A. Davis, studied for me[18] and showed were mainly the product of lime-depositing plants. We agreed that the same origin might apply to Precambrian.

It seems to me probable as a "hunch" that, while life began in a rather peculiar and individual environment, which the chemist and biologist after much experimenting have not yet been able to reproduce, it has gradually varied to fit varying environments and found a profit in new reactions, chemical and otherwise.

For instance, it seems as though in the later Precambrian, at a rather definite time in the earth's history, not the very beginning, the algae began to throw out lime carbonate, as the stoneworts (characeae) do now in our marl lakes. It was somewhat later that the organisms studied by E. C. Harder,[19] the iron-precipitating bacteria, learned to find a profit in the precipitation of iron oxides and initiated a world-wide age of iron deposits, and it was later yet before the conditions for them were so favorable that they abounded, as did the potato bugs about 1880, when I saw a windrow three inches high along high tide and as far as the eye could see along the Atlantic coast.

Still later, as Daly has pointed out,[20] came fishes, and a scavenger system was developed with a change in the quality of limestone. F. W. Clarke has also pointed out the effect of temperature in changing the proportions of lime and magnesia included in the shells of sandy animals.

As we have said, volcanic waters are generally acid and the ocean water is practically neutral. The rivers are high in sodium, lime, etc., combined with sulphate chlorine and CO_2 mainly, but a small amount of SiO_2. On reaching the ocean, the lime carbonate may largely be precipitated as limestone (directly or more likely indirectly), but the sodium carbonate or silicate may be thought of as converted into sodium chloride, while the silica is converted into the tests of the diatoms and the CO_2 is used by life in one way and another.

In the ocean the tendency to an increase of the ratio of sodium to chlorine was probably not uniform, for rainy climates and large land areas would furnish

[17] *Bul. Can. Mining Institute*, Nov., 1930.

[18] *Jour. Geol.*, 1900, Vol. 8, 1900, pp. 485–497.

[19] *U. S. Geological Survey*, Prof. Paper 113. See also Lane, *Geol. Mag.*, 1908, p. 485.

[20] *Bul. G. S. A.*, 20, 1909, pp. 153–170.

sodium more rapidly, while a large precipitation of salt would leave a residue in which the earthy chlorides were more abundant.

R. B. Newcombe tells me that a well at Muskegon, Michigan, 4,715 feet deep down to the St. Peter sandstone, has 59,785 of Na and K to 168,000 of Cl, a ratio of 0.353, while wells higher geologically (in the Devonian), but just as deep, have a higher ratio of Na to Cl. For instance, in a well near Midland, practically as deep down to the Sylvania sandstone just below the Devonian (4,697–4,700 feet), the ratio had risen to 0.4, and in the present ocean the ratio is 0.65.

In connate waters of the later Paleozoic, the ratio is usually from 0.44 to 0.53, as found by Reeves.[21] We must, however, remember that these and other buried waters struck by the oil wells have generally been more or less altered by diagenetic changes, by bacteria buried with them, or introduced later by circulation since burial of the strata, not by any means necessarily by circulation from the present surface, but by circulation from some ancient land surface which in leaching the limestone left it full of pores and caves and underground water channels[22] in which later petroleum could collect, ready to gush out when trapped. Such changes from old land surfaces in most cases seem to raise the proportion of sodium and of acid radicals other than chlorine, even though water is absorbed. For instance, the St. Peter's sandstone shows a fresh water 2,000 feet down. I have no doubt the normal oceanic Na : Cl ratio of St. Peter's time is less than 0.35 and nearer that of the Keweenawan, which seems to be near 0.08—the ratio of the time when hard parts and land animals may have developed, as we shall see.

But what about the life that has existed in this changing physical environment of the ocean?

While the single-celled forms multiplied in the water which brought them their food, those which showed they had a capacity to cooperate to help the circulation of sea water around through the mass had an advantage which led to the porifera or sponges which have a circulatory system which ultimately led to that of the blood of our veins.

Even though there was life even in the hot waters of the geysers, the chances are that somewhat cooler and somewhat less acid waters would on the whole be better for the activity of the protoplasm. While in the beginning there would be no limey shells in the acid or soft waters, and no tendency to produce them and if produced they would have been promptly dissolved, the time would come when the concentration passed the physiological optimum which doctors tell us is about eight parts per thousand. Then what? Some of the organisms would secrete some of the extra salts. If they were secreted internally, they might serve as a skeleton support. If they were secreted around the outside, they might serve as a shell-like protection. A leathery or shell-like protection might serve to protect from evaporation as well as attack. They could stand exposure to the air. Some of them might find themselves better off in streams where the water was somewhat too fresh, than in the ocean where the water became too salt. Others would find the reverse. So we find forms diverging, fitting themselves for different stations.

Thus we find in fresh-water forms various concentrations below, in salt water forms, concentrations above, and in land forms the concentrations just about eight parts per thousand.

While Quinton, who first emphasized these facts,[23] considered that concentration the original composition of the ocean, I maintained that it is more likely to be that of the ocean at the close of the Precambrian, *i.e.,* not 2,000 million years ago, but only some 500,000,000. We find the urge to secrete hard parts appears in the same geological period with a simultaneity in various lines of life that points to some changing factor in their common environment as the cause.

The Keweenawan, however, whether Cambrian, as I believe, or Precambian—the current work of Dr. Urry on the helium, radium, thorium ratio of its traps may have settled the question—was at any rate laid down under an oxidizing atmosphere, so that its red sandstones and weathered traps are much like those of later days. It is very different from the Keewatin, and the normal ratio of Na : Cl seems to be not far from this critical value.

When the ocean passed the physiological optimum, some forms were carried passively with it. Others, as has just been said, resisted by secreting shells, by development of a special circulatory fluid and by getting out on land. With the modification of environment came the command, "Modify to match, or migrate, or go to the morgue and mortify!" The annelids and the clam were fitted to stay in the mud, and they stayed. My ancestors "were fitted for higher things," and they migrated to find them.[24]

Various modifications fitted them for various stations in life. But the modification often came first,

[21] Yet he found for his Devonian brines the ratio, 0.355. Johns Hopkins University *Contributions to Geol.,* March, 1917, p. 65.

[22] See Howard, *Bul. Am. Ass. Pet. Geologists,* 12, Dec., 1918, p. 1153, and Newcombe, R. B., *Bul. G. S. A.,* 1931, p. 725.

[23] "L'eau de Mer Milieu Organique." *Cf.* "The Early Surroundings of Life," SCIENCE, August 2, 1907. "Isolation by Choice," SCIENCE, May 4, 1906, p. 702.

[24] See also H. Van Dyke's "Quatrain to a Recreant Clam."

as assured by the theory of preadaptation of Davenport and Cuénot.

If so, it is altogether likely that some organisms did not go to or find the place which they fitted.

Only those who had the sense to go to it or, if they were there accidentally, to stay in it would profit by their fitness and variation advantage! If their children inherited their variation and their sense, they would in turn profit by it. Thus a nerve reaction or variation, an intelligence correlative to the other variation was needed.

Some forms would be fitted for land life, could emerge from the sea with a circulation cut off from the sea yet retaining traces of its composition at the time they emerged, and a skin to prevent its evaporation too fast—just enough to keep them cool on hot days. In the new surroundings, which they alone fitted, they would find less competition. If they were eutopotropic, they would stay there and mate with others like-minded.

But once out on land, there is a wide variety of climate—from that of a tropical jungle or of a tropical desert to that of a Siberian desert or to that of the Antarctic continent. Yet almost everywhere we find forms of life, fitted so that they can survive and thrive in those surroundings. Sometimes they have to seek other surroundings to breed.

Now this we notice, that whether or no they fit into their surroundings, the higher life which is mobile does not have to stay there. Indeed, like the migrating bird, it often journeys far. Among the most wonderful journeys are those of the eels, from the center of the Atlantic to the fresh-water streams and back, and the salmon, from the fresh-water streams to the ocean and back.

In other words, with fitting the environment goes finding the environment that fits. Let us illustrate again.[25]

Before the Himalayas were nearly as high as at present, elephants roamed Asia. Some had less hair and were better fitted for the climate of India, others had more and were better fitted for the climate of Siberia. But there was nothing to prevent the hairy one going south. No doubt some did and got too hot and caught cold and died.

Little by little, however, there was a gradual segregation of the hairy to the north, the hairless to the south.

We will agree that there have been great changes of climate. Through these Nature commanded, "Modify or migrate." Some animals, preadapted, could obey the first alternative, others, sensibly eutopotropic, obeyed the second. Those without variability or intelligence perished.

[25] *Harvard Alumni Bulletin*, 1925, p. 649; *Tufts College Weekly*, Jan. 1910, p. 175–181.

This finding the place for which the organism is fit we call intelligence, or especially when it is hard for us to imagine that in the animal mind the movement is toward a clearly conscious goal, instinct. But in general, the higher animals seem to have instinct replaced more and more by conscious intelligence. Behavior which seems to be controlled by the future, by an aim or goal, we call intelligence, whereas action which we can predict from the past we call mechanical.

"Westward, the star of empire takes its way" describes in poetic language the spread of the race of man over the world after the last ice invasion. It is in part perhaps instinctive. It has culminated in my lifetime in the attainment of the North and South Poles, the battle of Manila, the entrance of Japan into the list of great powers, and the formation of the League of Nations after a world-wide war.

But the settlement of America was partly that of intelligent purpose. My Puritan forebears came with a definite aim, to construct a *commonwealth* (note the word "common") which should be nearer what they thought God wanted, a purer form of government in church and state.

Carl Schurz and the "Lateinsche Bauern" came to get a greater freedom and a more democratic government than then existed in their fatherland. Many before and since have come to America from many lands, the cream of their respective communities, because they were the more discontented and restless, who sought, like Abraham of old, a better land, or as the Pilgrim said, enlargement. These restless energetic souls, even though they may be classed themselves as dangerous radicals, may make fine sires. Many people who would think of Congressman Lindbergh as a dangerous radical would agree that he was a success as a parent, and that the United States stock would not have been improved by keeping him out.

My Uncle Daniel went from New England to Kansas in the days of bleeding Kansas. So his son enlisted in the days of the Spanish War and now finds himself in Honolulu.

In the development of the United States, in the pushing back of the frontier, in the development of the oil business, there has often been little conscious planning for the good of the whole, any more than there was in that wild stampede of individualists which opened the magnificent state of Oklahoma. It was partly "each for himself and the devil take the hindmost" and partly "there is plenty for all, help yourself. Uncle Sam can give every man a farm."

Twenty-odd years ago, called upon to speak at a banquet in Saginaw, about one o'clock in the morning, after a long evening of speeches, I told the Saginaw business men that when they ran out of other fuel, they could strike gas! I also told them I hoped they would not strike it before they had changed the state law to prevent overdrilling. They found it where I said, but they had not changed the state law as much as it should be changed, and even since I started writing this, a horrible tragedy of burning, involving some of my friends, has occurred, and may be due partly to overcrowded wells. Overcrowding is emphasized in this year's *Michigan Engineer*.

But, as, when the ocean grew too salt, survival was for those who could find a fit place in new conditions, so it is now. Conditions in America have changed. Our early towns grew helter-skelter. Now we have city-planning boards and the eutopotropic man, if he fits that kind of thing, will seek a decent, a beautiful and a well-laid-out town. No doubt, too, there will be for a good while helltowns, and people who find themselves most at home there will turn that way.

The era of expansion of the human race approaches its close. The era of organization, of cooperation dawns. Not only in the petroleum business, but in world affairs, the question is who has enough sense, enough intelligence to find his place, the place where he fits, and our Nation fits, to find its place in these new conditions.

> The old order changeth, yielding place to new
> And God fulfils himself in many ways
> Lest one good custom should corrupt the world.

We have been absorbing the gold of the world. We have more than half of it. We were gathering in the rest at a rate that would surely corner it. This has not been deliberately and intelligently done, but the result has been one factor in business depression. As we cornered gold, the price of everything else measured in gold went down. If continued, sooner or later debts payable in gold can no longer be paid. Shall we have intelligence to see this and arrange for some way in which the debts due us from Europe shall be paid in some work for world welfare, but not in gold? Shall we have sense enough to fit the new conditions and learn from Him who said, "He that would be greatest among you, let him be the servant of all." Or shall we, buzzing some clichés of isolation and independence and separation of politics and economics, continue to butt our head against the wall, kick against the pricks and squeal when we are hurt?

Years ago I was geologizing down South, and one noon we unhitched the mules from the buckboard and left them to eat their rations of corn from its rear while we sought a cooler spot under the shade of a tree a little out of sight.

After a little the noontide stillness was pierced by a tremendous vociferousness, unquestionably arising from one of the razorbacks. I said to my driver:

"Alex, one of those mules must have kicked a hog."

"Hit sounds lak hit."

The noise continued in undiminished volume. The air quivered.

"It must have broken her leg. Let's go and see."

We went over. The hog had too much sense, was too eutopotropic to get near the business end of the mule, but in reaching through the spokes of the wheel, the spokes caught her by the nape of the neck. As soon as she felt caught, she braced and the more she braced, the tighter she was held. But her vocal powers were not checked at all. We sat and laughed for a while. Then Alex put his foot on her neck. One magnificent squeal and off she trotted, unhurt.

Many animals have no more sense than the hog or the moth with the candle. They will draw tight the cord that holds or chokes them.

When I suggest a tax of two cents a thousand on gas produced, whether used or not, will I not be greeted with squeals of remonstrance as vigorous as that which greeted Doheny's investigation plan? Yet there is that which withholdeth more than is meet, but it tendeth to poverty. Those who protest may be much benefited.

How much better are we?

As geologists we use the present as a key to the past. From past and present we should be more able than many to outline the trend of things. There is the present duty on us to advise and warn our business associates and fellow citizens as to what the experience of the past billion years teaches.

Have we sense enough to fit ourselves to the rôle of a credit nation? Being the richest nation on earth, have we sense enough to know that pride goeth before a fall, or have we sense enough to wisely use our wealth as trustees for the world, in stamping out disease, in preserving ocean life, in studying the climate of the world, in building the beacons of the air, in educating men of science? It would be selfish for this audience to suggest that Germany pay part of her debts by giving scholarships in the advanced work of the universities to 400 of the American geologists out of work, yet it would accomplish a threefold object—not only relieve unemployment, but help Germany's task of paying reparations and improve our geologic skill.

So I do not emphasize this, but I would urge that it is senseless as a nation to shut our eyes and content ourselves with saying, "They borrowed, let them pay," without considering how they are to pay.

I have wondered if the policy of counting every admixture of the white and black races as black, allowing free marriage between black and colored and checking marriage between colored and white (though not entirely preventing breeding) was intelligent and would not inevitably and mathematically lead to a larger and larger preponderance of colored with more or less white blood; whether our attitude toward the Indians (which has led to persons like Mrs. Woodrow Wilson, Calvin Coolidge, Vice-President Curtis, and others) was wiser.

The American people are cramped by legislation and by a respect for tradition in the legal profession, which is not without advantage in retaining what is good from the past, and geologists are evolutionists rather than revolutionists. But it hinders greatly that adaptation to changing conditions which one finds in the frontiersmen.

It made it very hard to change the laws suited for the wet climate and rural conditions of England and the Emerald Isle regarding water rights so as to have a code suited to a land which is worthless without irrigation, or to handle the problems when great cities spend tens of millions and reach out tens of miles to remote watersheds crossing state lines for their water.

The great works of the present, like the Chicago drainage canal, affect men from Georgian Bay on the north side of Lake Huron to New Orleans. They are not state matters.

So again the flood of oil, due to the way in which you petroleum geologists have so successfully, too successfully, applied your science to the development of national resources, can not be handled by individual state action any more than can a Mississippi flood.

In these days of automobiles, to say nothing of airplanes, when in our smaller New England states a man can be in five states in an afternoon, is talk about throwing the control of the liquor traffic back into the hands of the states the buzzing of the June-bug?

Again, facing the problem of unemployment, modified as it is by the enormously increased powers of production, is it not necessary that some planning be done as to what and how much shall be produced? If some new invention puts whole communities out of business through no fault of their own, as the invention of rayon silk has crippled the making of cotton stockings, would it be too much to demand part of the invention royalties to rehabilitate and to teach those thrown out of work some new and useful work?

Should any one out of work be helped until he had been examined for the work to which he is pre-adapted? Possibly he may be out of work because he is no good at the job into which he drifted. Should a prerequisite for a dole be four hours a day of study?

All these are questions which require sound sense, a spirit proposed for progress, but guided by the experience of the past.

Fifty years ago Dr. Penrose and I were in Harvard together. Little did I dream that I should succeed him as president of the Geological Society of America, or that he would leave the society the magnificent endowment that will be a monument to his memory, more enduring than any erected in a cemetery. In the first place, there was no such society. In the second place, he was a freshman when I was a sophomore, and got his bachelor's degree a year later than I, though he received the degree of doctor of philosophy from Harvard two years before me, having the practically unique distinction of obtaining it at Harvard in two years after the A.B.

Now the large endowment brings to the Geological Society new conditions. Shall it be adaptable or eutopotropic? While I do not forget that word of our Saviour, "Where the carcass is there are the buzzards gathered together," I have faith to believe that we have sense enough to be eutopotropic, and will find in these larger conditions room for worthy expansion, that the new conditions may be to us as the expanding shell to Holmes' chambered nautilus:

> Build thee more stately mansions
> Oh, my soul,
> As the swift seasons roll.
> Let each new temple, nobler than the last,
> Shut thee from heaven with a dome more vast.

Environment, heredity—these are not all the factors in evolution. We must add our individuality as helmsman. Some of you have doubtless seen a yacht race. As a son of the Old Bay State, let me close with the following sonnet, dedicated, with his permission, to probably the most skilful helmsman in the United States, Charles Francis Adams—a sonnet which gives a picture of the three factors in evolution. Besides heredity and environment we have individuality—eutopotropism—sense enough to steer a skilful course, sense enough to find the fastest track.

THE RACE

Oh, see the sloops with sails that flash out bright
Against the ruffled sea and grayer sky
Along the horizon, when the waning light
Strikes fairly on the mainsails towering high.
They vanish as they come about to tack—
First one and then another, as for each
The helmsman picks her individual track,
Knowing his own boat's sails and lines and reach.
So, studying wind and wave and rip and tide,
Toward the desired haven they beat in.
Be breeze adverse or light, yet on they glide,
The skipper's wit counts much the race to win.
Our forebears give the boat, but we must steer
Across life's seas, though weather foul or clear.