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American Anthropologist, New Series, Vol. 45, No. 3, Part 1 (Jul. - Sep., 1943), 335-356.

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American Anthropologist is currently published by American Anthropological Association.

American Anthropologist

NEW SERIES

VOL. 45 JULY–SEPTEMBER, 1943 NO. 3, PART 1

ENERGY AND THE EVOLUTION OF CULTURE

By LESLIE A. WHITE

EVERYTHING in the universe may be described in terms of energy. Galaxies, stars, molecules, and atoms may be regarded as organizations of energy.[1] Living organisms may be looked upon as engines which operate by means of energy derived directly or indirectly from the sun. The civilizations, or cultures of mankind, also, may be regarded as a form or organization of energy. Culture is an organization of phenomena—material objects, bodily acts, ideas, and sentiments—which consists of or is dependent upon the use of symbols. Man, being the only animal capable of symbol-behavior, is the only creature to possess culture.[2] Culture is a kind of behavior. And behavior, whether of man, mule, plant, comet or molecule, may be treated as a manifestation of energy. Thus we see, on all levels of reality,[3] that phenomena lend themselves to description and interpretation in terms of energy. Cultural anthropology is that branch of natural science[4] which deals with matter-and-motion, i.e., energy, phenomena in cultural form, as biology deals with them in cellular, and physics in atomic, form.

The purpose of culture is to serve the needs of man. These needs are of two kinds: (1) those which can be served or satisfied by drawing upon resources within the human organism alone. Singing, dancing, myth-making, forming clubs or associations for the sake of companionship, etc., illustrate this kind of needs and ways of satisfying them. (2) The second class of needs can be satisfied only by drawing upon the resources of the external world, outside the human organism. Man must get his food from the external world. The tools, weapons, and other materials with which man provides himself with food, shelter from the elements, protection from his enemies, must likewise come from the external world. The satisfaction of spiritual and esthetic needs

[1] By "energy" we mean "the capacity for performing work."

[2] Cf. Leslie A. White, *The Symbol: The origin and basis of human behavior* (Philosophy of Science, Vol. 7, October, 1940), pp. 451–463.

[3] See Leslie A. White. *Science is Sciencing* (Philosophy of Science, Vol. 5, October, 1938), pp. 369–389, for a discussion of this general point of view.

[4] "Natural science" is a redundancy. All science is natural; if it is not natural it is not science.

through singing, dancing, myth-making, etc., is possible, however, only if man's bodily needs for food, shelter, and defense are met. Thus the whole cultural structure depends upon the material, mechanical means with which man articulates himself with the earth. Furthermore, the satisfaction of human needs from "inner resources" may be regarded as a constant,[5] the satisfaction of needs from the outer resources a variable. Therefore, in our discussion of cultural development we may omit consideration of the constant factor and deal only with the variable—the material, mechanical means with which man exploits the resources of nature.

The articulation-of-man-with-the-earth process may be analyzed and resolved into the following five factors: (1) the human organism, (2) the habitat, (3) the amount of energy controlled and expended by man, (4) the ways and means in which energy is expended, and (5) the human-need-serving product which accrues from the expenditure of energy. This is but another way of saying that human beings, like all other living creatures, exploit the resources of their habitat, in one way or another in order to sustain life and to perpetuate their kind.

Of the above factors, we may regard the organic factor as a constant. Although peoples obviously differ from each other physically, we are not able to attribute differences in culture to differences in physique (or "mentality"). In our study of culture, therefore, we may regard the human race as of uniform quality, i.e., as a constant, and, hence, we may eliminate it from our study.

No two habitats are alike; every habitat varies in time. Yet, in a study of culture as a whole,[6] we may regard the factor of habitat as a constant: we simply reduce the need-serving, welfare-promoting resources of all particular habitats to an average. (In a consideration of particular manifestations of culture we would of course have to deal with their respective particular habitats.) Since we may regard habitat as a constant, we exclude it, along with the human organism, from our study of the development of culture.

This leaves us, then, three factors to be considered in any cultural situation: (1) the amount of energy per capita per unit of time harnessed and put to work within the culture, (2) the technological means with which this energy is expended, and (3) the human need-serving product that accrues from the expenditure of energy. We may express the relationship between these factors in

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[5] Actually, of course, it is not wholly constant; there may be progress in music, myth-making, etc., regardless of technology. A men's club, however, is still a men's club, whether the underlying technology be simple and crude or highly developed. But, since the overwhelming portion of cultural development is due to technological progress, we may legitimately ignore that small portion which is not so dependent by regarding it a constant.

[6] "There is only one cultural reality that is not artificial, to wit: the culture of all humanity at all periods and in all places," R. H. Lowie, *Cultural Anthropology: a Science* (American Journal of Sociology, Vol. 42, 1936), p. 305.

the following simple formula: $E \times T = P$, in which E represents the amount of energy expended per capita per unit of time, T the technological means of its expenditure, and P the magnitude of the product per unit of time. This may be illustrated concretely with the following simple example: A man cuts wood with an axe. Assuming the quality of the wood and the skill of the workman to be constant, the amount of wood cut in a given period of time, an hour say, depends, on the one hand upon the amount of energy the man expends during this time: the more energy expended, the more wood cut. On the other hand, the amount of wood cut in an hour depends upon the kind of axe used. Other things being equal, the amount of wood cut varies with the quality of the axe: the better the axe the more wood cut. Our workman can cut more wood with an iron, or steel, axe than with a stone axe.

The efficiency with which human energy is expended mechanically depends upon the bodily skills of the persons involved, and upon the nature of the tools employed. In the following discussion we shall deal with skill in terms of averages. It is obvious, of course, that, other things being equal, the product of the expenditure of human energy varies directly as the skill employed in the expenditure of this energy. But we may reduce all particular skills, in any given situation, to an average, which, being constant may be eliminated from our consideration of culture growth. Hereafter, then, when we concern ourselves with the efficiency with which human energy is expended mechanically, we shall be dealing with the efficiency of tools only.

With reference to tools, man can increase the efficiency of the expenditure of his bodily energy in two ways: by improving a tool, or by substituting a better tool for an inferior one. But with regard to any given kind of tool, it must be noted that there is a point beyond which it cannot be improved. The efficiency of various tools of a certain kind varies; some bows are better than others. A bow, or any other implement, may vary in efficiency between 0 per cent and 100 per cent. But there is a maximum, theoretically as well as actually, which cannot be exceeded. Thus, the efficiency of a canoe paddle can be raised or lowered by altering its length, breadth, thickness, shape, etc. Certain proportions or dimensions would render it useless, in which case its efficiency would be 0 per cent. But, in the direction of improvement, a point is reached, ideally as well as practically, when no further progress can be made—any further change would be a detriment. Its efficiency is now at its maximum (100 per cent). So it is with a canoe, arrow, axe, dynamo, locomotive, or any other tool or machine.

We are now ready for some generalizations about cultural development. Let us return to our formula, but this time let us write it $E \times F = P$, in which E and P have the same values as before—E, the amount of energy expended; P the product produced—while F stands for the efficiency of the mechnical means with which the energy is expended. Since culture is a mechanism for serving

human needs, cultural development may be measured by the extent to which, and the efficiency with which, need-serving goods or services are provided. P, in our formula, may thus stand for the total amount of goods or services produced in any given cultural situation. Hence P represents the status of culture, or, more accurately, the degree of cultural development. If, then, F, the efficiency with which human energy is expended, remains constant, then P, the degree of cultural development, will vary as E, the amount of energy expended per capita per year[7] varies:

$$\frac{E_1 \times F}{E_2 \times F} = \frac{P_1}{P_2}$$

Thus we obtain the first important law of cultural development: *Other things being equal, the degree of cultural development varies directly as the amount of energy per capita per year harnessed and put to work.*

Secondly, if the amount of energy expended per capita per unit of time remains constant, then P varies as F:

$$\frac{E \times F_1}{E \times F_2} = \frac{P_1}{P_2}$$

and we get the second law of cultural development: *Other things being equal, the degree of cultural development varies directly as the efficiency of the technological means with which the harnessed energy is put to work.*

It is obvious, of course, that E and F may vary simultaneously, and in the same or in opposite directions. If E and F increase simultaneously P will increase faster, naturally, than if only one increased while the other remained unchanged. If E and F decrease simultaneously P will decrease more rapidly than if only one decreased while the other remained constant. If E increases while F decreases, or vice versa, then P will vary or remain unchanged, depending upon the magnitude of the changes of these two factors and upon the proportion of one magnitude to the other. If an increase in E is balanced by a decrease in F, or vice versa, then P will remain unchanged. But should E increase faster than F decreases, or vice versa, then P would increase; if E decreases faster than F increases, or vice versa, then P would decrease.

We have, in the above generalizations *the* law of cultural evolution: *culture develops when the amount of energy harnessed by man per capita per year is increased; or as the efficiency of the technological means of putting this energy to work is increased; or, as both factors are simultaneously increased.*

All living beings struggle to live, to perpetuate their respective kinds. In the

[7] We say "per year" although "per unit of time" would serve as well, because in concrete cultural situations a year would embrace the full round of the seasons and the occupations and actions appropriate thereto.

human species the struggle for survival assumes the cultural form. The human struggle for existence expresses itself in a never-ending attempt to make of culture a more effective instrument with which to provide security of life and survival of the species. And one of the ways of making culture a more powerful instrument is to harness and to put to work within it more energy per capita per year. Thus, wind, and water, and fire are harnessed; animals are domesticated, plants cultivated; steam engines are built. The other way of improving culture as an instrument of adjustment and control is to invent new and better tools and to improve old ones. Thus energy for culture-living and culture-building is augmented in quantity, is expended more efficiently, and culture advances.

Thus we know, not only *how* culture evolves, but *why*, as well. The urge, inherent in all living species, to live, to make life more secure, more rich, more full, to insure the perpetuation of the species, seizes upon, when it does not produce, better[8] (i.e., more effective) means of living and surviving. In the case of man, the biological urge to live, the power to invent and to discover, the ability to select and use the better of two tools or ways of doing something—these are the factors of cultural evolution. Darwin could tell us the consequences of variations, but he could not tell us how these variations were produced. We know the motive force as well as the means of cultural evolution. The culturologist knows more about cultural evolution than the biologist, even today, knows about biological evolution.[9]

A word about man's motives with regard to cultural development. We do not say that man deliberately set about to improve his culture. It may well have been, as Morgan[10] suggested, decades before Lowie[11] emphasized the same point, that animals were first domesticated through whim or caprice rather than for practical, utilitarian reasons. Perhaps agriculture came about through accident. Hero's steam engine was a plaything. Gunpowder was first used to make pretty fireworks. The compass began as a toy. More than this, we know

[8] The cultural evolutionists have been critized for identifying progress with evolution by pointing out that these two words are not synonymous. It is as true as it is obvious that they are not synonymous—in the dictionary. But by and large, in the history of human culture, progress and evolution *have gone hand in hand.*

[9] See Tylor, *Primitive Culture*, Vol. I, p. 14 (London, 1929 printing) for another respect in which, in theory of evolution, "the student of the habits of mankind has a great advantage over the student of the species of plants and animals."

[10] "Commencing probably with the dog . . . followed . . . by the capture of the young of other animals and rearing them, not unlikely, *from the merest freak of fancy*, it required time and experience to discover the utility of each . . . " (emphasis ours). Morgan, *Ancient Society*, p. 42 (Holt ed.).

[11] *Introduction to Cultural Anthropology* (New York, 1940 ed.) pp. 51–52. In this argument Lowie leans heavily upon Eduard Hahn, whose work, incidentally, appeared many years after *Ancient Society* ("Subsistence," p. 303, in *General Anthropology*, F. Boas, ed., New York, 1938; *History of Ethnological Theory*, p. 112 ff., New York, 1937).

that peoples often resolutely oppose technological advances with a passionate devotion to the past and to the gods of their fathers. But all of this does not alter the fact that domesticated animals and cultivated plants have been used to make life more secure. Whatever may have been the intentions and motives (if any) of the inventors or discoverers of the bow and arrow, the wheel, the furnace and forge, the steam engine, the microscope, etc., the fact remains that these things have been seized upon by mankind and employed to make life more secure, comfortable, pleasant, and permanent. So we may disregard the psychological circumstances under which new cultural devices were brought into being. What is significant to the cultural evolutionist is that inventions and discoveries have been made, new tools invented, better ways of doings things found, and that these improved tools and techniques are kept and used until they are in turn replaced.

So much for the laws, or generalizations derived from our basic formula. Let us turn now to concrete facts and see how the history of culture is illuminated and made intelligible by these laws.

In the beginning of culture history, man had only the energy of his own body under his control and at his disposal for culture-living and culture-building. And for a very long period of time this was almost the only source of energy available to him. Wind, water, and fire were but rarely used as forms of energy. Thus we see that, in the first stage of cultural development, the only source of energy under man's control and at his disposal for culture-building was, except for the insignificant and limited use of wind, water and fire, his own body.

The amount of energy that could be derived from this source was very small. The amount of energy at the disposal of a community of 50, 100, or 300 persons would be 50, 100, or 300 times the energy of the average member of the community, which, when infants, the sick, the old and feeble are considered, would be considerably less than one "man-power" per capita. Since one "man-power" is about one-tenth of one horse-power, we see that the amount of energy per capita in the earliest stage of cultural development was very small indeed—perhaps 1/20th horsepower per person.

Since the amount of energy available for culture building in this stage was finite and limited, the extent to which culture could develop was limited. As we have seen, when the energy factor is a constant, cultural progress is made possible only by improvements in the means with which the energy is expended, namely, the technology. Thus, in the human-energy stage of cultural development progress is achieved only by inventing new tools—the bow and arrow, harpoon, needle, etc., or by improving old ones—new techniques of chipping flint implements, for example. But when man has achieved maximum efficiency in the expenditure of energy, and when he has reached the limits of his finite bodily energy resources, then his culture can develop no further. Unless he can harness additional quantities of energy—by tapping new sources—cultural development will come to an end. Man would have re-

mained on the level of savagery[12] indefinitely if he had not learned to augment the amount of energy under his control and at his disposal for culture-building by harnessing new sources of energy. This was first accomplished by the domestication of animals and by the cultivation of plants.

Man added greatly to the amount of energy under his control and at his disposal for culture-building when he domesticated animals and brought plants under cultivation. To be sure, man nourished himself with meat and grain and clothed himself with hides and fibers long before animal husbandry and agriculture came into being. But there is a vast difference between merely exploiting the resources of nature and of harnessing the forces of nature. In a wild food economy, a person, under given environmental conditions, expends a certain amount of energy (we will assume it is an average person so that the question of skill may be ignored) and in return he will secure, on the average, so much meat, fish, or plant food. But the food which he secures is itself a form and a magnitude of energy. Thus the hunter or wild plant-food gatherer exchanges one magnitude of energy for another: m units of labor for n calories of food. The ratio between the magnitude of energy obtained in the form of food and the magnitude expended in hunting and gathering may vary. The amount obtained may be greater than, less than (in which case the hunter-gatherer would eventually perish), or equal to, the amount expended. But although the ratio may vary from one situation to another, it is in any particular instance fixed: that is, the magnitude of energy-value of the game taken or plant-food gathered remains constant between the time that it is obtained and the time of its consumption. (At least it does not increase, it may in some instances decrease through natural deterioration.)

In a wild food economy, an animal or a plant is of value to man only after it has ceased to be an animal or a plant, i.e., a living organism. The hunter kills his game, the gatherer digs his roots and bulbs, plucks the fruit and seeds. It is different with the herdsman and the farmer. These persons make plants and animals work for them.

Living plants and animals are biochemical mechanisms which, of themselves, accumulate and store up energy derived originally from the sun. Under agriculture and animal husbandry these accumulations can be appropriated and utilized by man periodically in the form of milk, wool, eggs, fruits, nuts, seeds, sap, and so on. In the case of animals, energy generated by them may be utilized by man in the form of work, more or less continuously throughout their lifetime. Thus, when man domesticated animals and brought plants under cultivation, he harnessed powerful forces of nature, brought them under his control, and made them work for him just as he has harnessed rivers and made them run mills and dynamos, just as he has harnessed the tremendous

[12] Following Morgan and Tylor, we use "savagery" to designate cultures resting upon a wild-food basis, "barbarism" for cultures with a domestic food basis. Our use of "civilization," however, differs from that of Tylor and Morgan (see p. 355).

reservoirs of solar energy that are coal and oil. Thus the difference between a wild plant and animal economy and a domestic economy is that in the former the return for an expenditure of human energy, no matter how large, is fixed, limited, whereas in agriculture and animal husbandry the initial return for the expenditure of human labor, augments itself indefinitely. And so it has come about that with the development and perfection of the arts of animal husbandry and agriculture—selective breeding, protection from their competitors in the Darwinian struggle for survival, feeding, fertilizer, irrigation, drainage, etc.—a given quantity of human labor produces much more than it could before these forces were harnessed. It is true, of course, that a given amount of human labor will produce more food in a wild economy under exceptionally favorable circumstances,—such, e.g., as in the Northwest Coast of America where salmon could be taken in vast numbers with little labor, or in the Great Plains of North America where, after the introduction of the horse and in favorable circumstances, a large quantity of bison meat could be procured with but little labor, —than could be produced by a feeble development of agriculture in unfavorable circumstances. But history and archeology prove that, by and large, the ability of man to procure the first necessity of life, food, was tremendously increased by the domestication of animals and by the cultivation of plants. Cultural progress was extremely rapid after the origin of agriculture.[13] The great civilizations of China, India, Mesopotamia, Egypt, Mexico, and Peru sprang up quickly after the agricultural arts had attained to some degree of development and maturity. This was due, as we have already observed, to the fact that, by means of agriculture man was able to harness, control, and put to work for himself powerful forces of nature. With greatly augmented energy resources man was able to expand and develop his way of life, i.e., his culture.

In the development of culture agriculture is a much more important and powerful factor than animal husbandry.[14] This is because man's control over the forces of nature is more immediate and more complete in agriculture than in animal husbandry. In a pastoral economy man exerts control over the animals only, he merely harnesses solar energy in animal form. But the animals themselves are dependent upon wild plants. Thus pastoral man is still dependent to a great extent upon the forces and caprices of nature. But in agriculture, his control is more intimate, direct, and, above all, greater. Plants receive and store up energy directly from the sun. Man's control over plants is direct and immediate. Further independence of nature is achieved by means of irrigation, drainage, and fertilizer. To be sure, man is always dependent

[13] "Finds in the Near East seem to indicate that the domestication of plants and animals in that region was followed by an extraordinary flowering of culture," Ralph Linton, *The Present Status of Anthropology* (Science, Vol. 87, 1938), p. 245.

[14] But this does not mean that agriculture *must be preceded* by a pastoral economy in the course of cultural development. Contrary to a notion current nowadays, none of the major evolutionists ever maintained that farming must be preceded by herding.

upon nature to a greater or less extent; his control is never complete. But his dependence is less, his control greater, in agriculture than in animal husbandry. The extent to which man may harness natural forces in animal husbandry is limited. No matter how much animals are improved by selective breeding, no matter how carefully they are tended—defended from beasts of prey, protected from the elements—so long as they are dependent upon wild plant food, there is a limit, imposed by nature, to the extent to which man can receive profitable returns from his efforts expended on his herds. When this limit has been reached no further progress can be made. It is not until man controls also the growth of the plants upon which his animals feed that progress in animal husbandry can advance to higher levels. In agriculture, on the other hand, while there may be a limit to the increase of yield per unit of human labor, this limit has not yet been reached, and, indeed it is not yet even in sight. Thus there appears to be a limit to the return from the expenditure of a given amount of human labor in animal husbandry. But in agriculture this technological limit, if one be assumed to exist, lies so far ahead of us that we cannot see it or imagine where it might lie.

Added to all of the above, is the familiar fact that a nomadic life, which is customary in a pastoral economy, is not conducive to the development of advanced cultures. The sedentary life that goes with agriculture is much more conducive to the development of the arts and crafts, to the accumulation of wealth and surpluses, to urban life.

Agriculture increased tremendously the amount of energy per capita available for culture-building, and, as a consequence of the maturation of the agricultural arts, a tremendous growth of culture was experienced. Cultural progress was very slow during Eolithic and Paleolithic times. But after a relatively brief period in the Neolithic age, during which the agricultural arts were being developed, there was a tremendous acceleration of culture growth, and the great cultures of China, India, Mesopotamia, Egypt, Mexico, and Peru, came rapidly into being.

The sequence of events was somewhat as follows: agriculture transformed a roaming population into a sedentary one. It greatly increased the food supply, which in turn increased the population. As human labor became more productive in agriculture, an increasing portion of society became divorced from the task of food-getting, and was devoted to other occupations. Thus society becomes organized into occupational groups: masons, metal workers, jade carvers, weavers, scribes, priests. This has the effect of accelerating progress in the arts, crafts, and sciences (astronomy, mathematics, etc.), since they are now in the hands of specialists, rather than jacks-of-all-trades. With an increase in manufacturing, added to division of society into occupational groups, comes production for exchange and sale (instead of primarily for use as in tribal society), mediums of exchange, money, merchants, banks, mortgages, debtors, slaves. An accumulation of wealth and competition for favored regions provoke

wars of conquest, and produce professional military and ruling classes, slavery and serfdom. Thus agriculture wrought a profound change in the life-and-culture of man as it had existed in the human-energy stage of development.

But the advance of culture was not continuous and without limit. Civilization had, in the main, reached the limit of its development on the basis of a merely agricultural and animal husbandry technology long before the next great cultural advance was initiated by the industrial revolution. As a matter of fact, marked cultural recessions took place in Mesopotamia, Egypt, Greece, Rome, perhaps in India, possibly in China. This is not to say that no cultural progress whatsoever was made; we are well aware of many steps forward from time to time in various places. But so far as general type of culture is concerned, there is no fundamental difference between the culture of Greece during the time of Archimedes and that of Western Europe at the beginning of the eighteenth century.

After the agricultural arts had become relatively mature, some six, eight or ten thousand years before the beginning of the Christian era, there was little cultural advance until the nineteenth century A.D. Agricultural methods in Europe and the United States in 1850 differed very little from those of Egypt of 2000 B.C. The Egyptians did not have an iron plow, but otherwise there was little difference in mode of production. Even today in many places in the United States and in Europe we can find agricultural practices which, the use of iron excepted, are essentially like those of dynastic Egypt. Production in other fields was essentially the same in western Europe at the beginning of the eighteenth (we might almost say nineteenth) century as in ancient Rome, Greece, or Egypt. Man, as freeman, serf, or slave, and beasts of burden and draft animals, supplemented to a meager extent by wind and water power, were the sources of energy. The Europeans had gunpowder whereas the ancients did not. But gunpowder cannot be said to be a culture-builder.[15] There was no essential difference in type of social—political and economic—institutions. Banks, merchants, the political state, great land-owners, guilds of workmen, and so on were found in ancient Mesopotamia, Greece, and Rome.

Thus we may conclude that culture had developed about as far as it could upon the basis of an agricultural-animal husbandry economy, and that there were recessions from peaks attained in Mesopotamia, Egypt, Greece and Rome long before the beginning of the eighteenth century A.D. We may conclude

[15] It is true, of course, that powder is used in blasting in quarries, etc., and is to this extent a motive force in culture building. But energy employed in this way is relatively insignificant quantitatively.

The bow and arrow inaugurated cultural advance because in its economic context it provided man with food in greater quantity or with less effort. The gun, in its hunting context, has had the opposite effect, that of reducing the food supply by killing off the game. In their military contexts, neither the bow and arrow or the gun has been a culture builder. The mere conquest or extermination of one tribe or nation by another, the mere change from one dynasty or set of office holders to another, is not culture building.

further, that civilization would never have advanced substantially beyond the levels already reached in the great cultures of antiquity if a way had not been found to harness a greater magnitude of energy per capita per unit of time, by tapping a new source of energy: fuel.

The invention of the steam engine, and of all subsequent engines which derive power from fuels, inaugurated a new era in culture history. When man learned to harness energy in the form of fuel he opened the door of a vast treasure house of energy. Fuels and engines tremendously increased the amount of energy under man's control and at his disposal for culture-building. The extent to which energy has been thus harnessed in the modern world is indicated by the eminent physicist, Robert A. Millikan as follows:[16]

> In this country [the U. S. A.] there is now expended about 13.5 horsepower hours per day per capita—the equivalent of 100 human slaves for each of us; in England the figure is 6.7, in Germany 6.0, in France 4.5; in Japan 1.8, in Russia 0.9, in China, 0.5.

Let us return now, for a moment, to our basic principle—culture develops as (1) the amount of energy harnessed and put to work per capita per unit of time increases, and (2) as the efficiency of the means with which this energy is expended increases—and consider the evolution of culture from a slightly different angle. In the course of human history various sources of energy are tapped and harnessed by man and put to work at culture-living and culture-building. The original source of energy was, as we have seen, the human organism. Subsequently, energy has been harnessed in other forms—agriculture, animal husbandry, fire,[17] wind, water, fuel.[17] Energy is energy, and from the point of view of technology it makes no difference whether the energy with which a bushel of wheat is ground comes from a free man, a slave,[18] an ox, the flowing stream or a pile of coal. But it makes a big difference to human beings where the energy comes from,[19] and an important index of cultural development is derived from this fact.

To refer once more to our basic equation: On the one hand we have energy expended; on the other, human need-serving goods and services are produced.

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[16] *Science and the World Tomorrow* (Scientific Monthly, Sept. 1939) p. 211. These figures do not, however, tell the whole story for they ignore the vast amount of energy harnessed in the form of cultivated plants and domestic animals.

[17] We may be permitted thus to distinguish two different ways of harnessing energy although each involves fire and fuel. By "fire" we indicate such energy uses of fire which preceded the steam engine—clearing forests, burning logs to make dugout canoes, etc. By "fuel" we designate energy harnessed by steam, gasoline, etc., engines.

[18] Technologically a freeman and a slave are equal, both being energy in homo sapiens form. Sociologically, there is, of course, a vast difference between them. Sociologically a slave is not a human being; he is merely a beast of burden who can talk.

[19] According to E. H. Hull, of the General Electric Research Laboratory, the power equivalent of "a groaning and sweating slave" is "75 watts of electricity, which most of us can buy at the rate of two-fifths of a cent an hour." *Engineering: Ancient and Modern* (Scientific Monthly, November, 1939), p. 463.

Culture advances as these two factors increase, hand in hand. But the energy component is resolvable into two factors: the human energy, and the non-human energy, factors. Of these, the human energy factor is a constant; the non-human energy factor, a variable. The increase in quantity of need-serving goods goes hand in hand with an increase in the amount of non-human energy expended. But, since the human energy factor remains constant, an increase in amount of goods and services produced means more goods and services per unit of human labor. Hence, we obtain the law: *Other things being equal, culture evolves as the productivity of human labor increases.*

In Savagery (wild food economy) the productivity of human labor is low; only a small amount of human need-serving goods and services are produced per unit of human energy. In Barbarism (agriculture, animal husbandry), this productivity is greatly increased. And in Civilization (fuels, engines) it is still further increased.

We must now consider another factor in the process of cultural development, and an important one it is, viz., the *social system within which energy is harnessed and put to work.*

We may distinguish two kinds of determinants in social organization, two kinds of social groupings. On the one hand we have social groupings which serve those needs of man which can be fed by drawing upon resources within man's own organism: clubs for companionship, classes or castes in so far as they feed the desire for distinction, will serve as examples. On the other hand, social organization is concerned with man's adjustment to the external world; social organization *is* the way in which human beings organize themselves for the three great processes of adjustment and survival—food getting, defense from enemies, protection from the elements. Thus, we may distinguish two factors in any social system, those elements which are *ends in themselves*, which we may call E; and elements which are *means to ends* (food, defense, etc.) which we may term M.

In any social system M is more important than E, because E is dependent upon M. There can be no men's clubs or classes of distinction unless food is provided and enemies guarded against. In the development of culture, moreover, we may regard E as a constant: a men's club is a men's club whether among savage or civilized peoples. Being a constant, we may ignore factor E in our consideration of cultural evolution and deal only with the factor M.

M is a variable factor in the process of cultural evolution. It is, moreover, a dependent variable, dependent upon the technological way in which energy is harnessed and put to work. It is obvious, of course, that it is the technological activities of hunting people that determine, in general, their form of social organization (in so far as that social organization is correlated with hunting rather than with defense against enemies). We of the United States have a certain type of social system (in part) because we have factories, railroads,

automobiles, etc.; we do not possess these things *as a consequence* of a certain kind of social system. Technological systems engender social systems rather than the reverse. Disregarding the factor E, social organization is to be regarded as the way in which human beings organize themselves to wield their respective technologies. Thus we obtain another important law of culture: *The social organization (E excluded) of a people is dependent upon and determined by the mechanical means with which food is secured, shelter provided, and defense maintained.* In the process of cultural development, *social evolution is a consequence of technological evolution.*

But this is not the whole story. While it is true that social systems are engendered by, and dependent upon, their respective underlying technologies, it is also true that social systems condition the operation of the technological systems upon which they rest; the relationship is one of mutual, though not necessarily equal, interaction and influence. A social system may foster the effective operation of its underlying technology or it may tend to restrain and thwart it. In short, in any given situation the social system may play a progressive role or it may play a reactionary role.

We have noted that after the agricultural arts had attained a certain degree of development, the great civilizations of China, India, Egypt, the Near East, Central America and Peru came rapidly into being as a consequence of the greatly augmented energy resources of the peoples of these regions. But these great civilizations did not continue to advance indefinitely. On the contrary they even receded from maximum levels in a number of instances. Why did they not continue progressively to advance? According to our law culture will advance, other things being equal, as long as the amount of energy harnessed and put to work per capita per unit of time increases. The answer to our question, Why did not these great cultures continue to advance? is, therefore, that the amount of energy per capita per unit of time, *ceased to increase*, and, furthermore, the efficiency of the means with which this energy was expended *was not advanced beyond a certain limit.* In short, there was no fundamental improvement in the agricultural arts from say 2000 B. C. to 1800 A. D.

The next question is, Why did not the agricultural arts advance and improve during this time? We know that the agricultural arts are still capable of tremendous improvement, and the urge of man for plenty, security and efficiency was as great then as now. Why, then, did agriculture fail to progress beyond a certain point in the great civilizations of antiquity? The answer is, The social system, within which these arts functioned, curbed further expansion, thwarted progress.

All great civilizations resting upon intensive agriculture are divided into classes: a ruling class and the masses who are ruled. The masses produced the means of life. But the distribution of these goods is in accordance with rules which are administered by the ruling class. By one method of control or

another—by levies, taxes, rents, or some other means—the ruling class takes a portion of the wealth produced by the masses from them, and consumes it according to their liking or as the exigencies of the time dictate.

In this sort of situation cultural advancement may cease at a certain point for lack of incentive. No incentive to progress came from the ruling class in the ancient civilizations of which we are speaking. What they appropriated from their subjects they consumed or wasted. To obtain more wealth the ruling class merely increased taxes, rents, or other levies upon the producers of wealth. This was easier, quicker, and surer than increasing the efficiency of production and thereby augmenting the total product. On the other hand, there was no incentive to progress among the masses—if they produced more by increasing efficiency it would only mean more for the tax-gatherers of the ruling class. The culture history of China during the past few centuries, or indeed, since the Han dynasty, well illustrates situations of this sort.

We come then to the following conclusion: *A social system may so condition the operation of a technological system as to impose a limit upon the extent to which it can expand and develop. When this occurs, cultural evolution ceases.* Neither evolution nor progress in culture is inevitable (neither Morgan nor Tylor ever said, or even intimated, that they are). When cultural advance has thus been arrested, it can be renewed only by tapping some new source of energy and by harnessing it in sufficient magnitude to burst asunder the social system which binds it. Thus freed, the new technology will form a new social system, one congenial to its growth, and culture will again advance until, perhaps, the social system once more checks it.

It seems quite clear that mankind would never have advanced materially beyond the maximum levels attained by culture between 2000 B. C. and 1700 A. D. had it not tapped a new source of energy (fuel) and harnessed it in substantial magnitudes. The speed with which man could travel, the range of his projectiles, and many other things, could not have advanced beyond a certain point had he not learned to harness more energy in new forms. And so it was with culture as a whole.

The steam engine ushered in a new era. With it, and various kinds of internal combustion engines, the energy resources of vast deposits of coal and oil were tapped and harnessed in progressively increasing magnitudes. Hydroelectric plants contributed a substantial amount from rivers. Populations grew, production expanded, wealth increased. The limits of growth of the new technology have not yet been reached; indeed, it is probably not an exaggeration to say that they have not yet even been foreseen, so vast are the possibilities and so close are we still to the beginning of this new era. But already the new technology has come into conflict with the old social system. The new technology is being curbed and thwarted. The progressive tendencies of the new technology are being held back by a social system that was adapted to the pre-fuel technology. This fact has become commonplace today.

In our present society, goods are produced for sale at a profit. To sell one must have a market. Our market is a world market, but it is, nevertheless, finite in magnitude. When the limit of the market has been reached production ceases to expand: no market, no sale; no sale, no profit; no profit, no production. Drastic curtailment of production, wholesale destruction of surpluses follow. Factories, mills, and mines close; millions of men are divorced from industrial production and thrown upon relief. Population growth recedes. National incomes cease to expand. Stagnation sets in.

When, in the course of cultural development, the expanding technology comes into conflict with the social system, one of two things will happen: either the social system will give way, or technological advance will be arrested. If the latter occurs, cultural evolution will, of course, cease. The outcome of situations such as this is not preordained. The triumph of technology and the continued evolution and progress of culture are not assured merely because we wish it or because it would be better thus. In culture as in mechanics, the greater force prevails. A force is applied to a boulder. If the force be great enough, the rock is moved. If the rock be large enough to withstand the force it will remain stationary. So in the case of technology-institutions conflicts: if the force of the growing technology be great enough the restraining institutions will give way; if this force is not strong enough to overcome institutional opposition, it must submit to it.

There was undoubtedly much institutional resistance to the expanding agricultural technology in late neolithic times. Such staunch institutions as the tribe and clan which had served man well for thousands of years did not give way to the political state without a fight; the "liberty, equality and fraternity" of primitive society were not surrendered for the class-divided, serf and lord, slave and master, society of feudalism without a struggle. But the ancient and time-honored institutions of tribal society could not accommodate the greatly augmented forces of the agricultural technology. Neither could they successfully oppose these new forces. Consequently, tribal institutions gave way and a new social system came into being.

Similarly in our day, our institutions have shown themselves incapable of accommodating the vast technological forces of the Power Age. What the outcome of the present conflict between modern fuel technology and the social system of an earlier era will be, time alone will tell. It seems likely, however, that the old social system is now in the process of destruction. The tremendous forces of the Power Age are not to be denied. The great wars of the twentieth century derive their chief significance from this fact: they are the means by which an old social order is to be scrapped, and a new one to be brought into being. The first World War wiped out the old ruling families of the Hapsburgs, Romanoffs, and Hohenzollerns, hulking relics of Feudalism, and brought Communist and Fascist systems into being. We do not venture to predict the social changes which the present war will bring about. But we may confident-

ly expect them to be as profound and as far-reaching as those effected by World War I.

Thus, in the history of cultural evolution, we have witnessed one complete cultural revolution, and the first stage of a second. The technological transition from a wild food economy to a relatively mature agricultural and animal husbandry economy was followed by an equally profound institutional change: from tribal society to civil society. Thus the first fundamental and all-inclusive cultural change, or revolution, took place. At the present time we are entering upon the second stage of the second great cultural revolution of human history. The Industrial Revolution was but the first stage, the technological stage, of this great cultural revolution. The Industrial Revolution has run its course, and we are now entering upon the second stage, one of profound institutional change, of social revolution. Barring collapse and chaos, which is of course possible, a new social order will emerge. It appears likely that the human race will occupy the earth for some million years to come. It seems probable, also, that man, after having won his way up through savagery and barbarism, is not likely to stop, when at last he finds himself upon the very threshold of civilization.

The key to the future, in any event, lies in the energy situation. If we can continue to harness as much energy per capita per year in the future as we are doing now, there is little doubt but that our old social system will give way to a new one, a new era of civilization. Should, however, the amount of energy that we are able to harness diminish materially, then culture would cease to advance or even recede. A return to a cultural level comparable to that of China during the Ming dynasty is neither inconceivable nor impossible. It all depends upon how man harnesses the forces of nature and the extent to which this is done.

At the present time "the petroleum in sight is only a twelve year supply, . . . and new discoveries [of oil] are not keeping pace with use."[20] Coal is more abundant. Even so, many of the best deposits in the United States—which has over half of the world's known coal reserves—will some day be depleted. "Eventually, no matter how much we conserve, this sponging off past ages for fossil energy must cease . . .What then?"[21] The answer is, of course, that culture will decline unless man is able to maintain the amount of energy harnessed per capita per year by tapping new sources.

Wind, water, waves, tides, solar boilers, photochemical reactions, atomic energy, etc., are sources which might be tapped or further exploited. One of the most intriguing possibilities is that of harnessing atomic energy. When the nucleus of an atom of uranium (U 235) is split it "releases 200,000,000 electron

[20] C. C. Furnas, *Future Sources of Power* (Science, Nov. 7, 1941), p. 425.
[21] *Ibid.*, p. 426.

volts, the largest conversion of mass into energy that has yet been produced by terrestrial means."[22] Weight for weight, uranium (as a source of energy produced by nuclear fission) is 5,000,000 times as effective as coal.[23] If harnessing sub-atomic energy could be made a practical success, our energy resources would be multiplied a thousand fold. As Dr. R. M. Langer,[24] research associate in physics at California Institute of Technology, has put it:

> The face of the earth will be changed . . . Privilege and class distinctions . . . will become relics because things that make up the good life will be so abundant and inexpensive. War will become obsolete because of the disappearance of those economic stresses that immemorially have caused it . . . The kind of civilization we might expect . . . is so different in kind from anything we know that even guesses about it are futile.

To be able to harness sub-atomic energy would, without doubt, create a civilization surpassing sober imagination of today. But not everyone is as confident as Dr. Langer that this advance is imminent. Some experts have their doubts, some think it a possibility. Time alone will tell.

But there is always the sun, from which man has derived all of his energy, directly or indirectly, in the past. And it may be that it will become, directly, our chief source of power in the future. Energy in enormous amounts reaches the earth daily from the sun. "The average intensity of solar energy in this latitude amounts to about 0.1 of a horse power per square foot" (Furnas, p. 426). "Enough energy falls on about 200 square miles of an arid region like the Mojave Desert to supply the [present needs of the] United States" (Furnas, p. 427). But the problem is, of course, to harness it effectively and efficiently.[25] The difficulties do not seem insuperable. It will doubtless be done, and probably before a serious diminution of power from dwindling resources of oil and coal overtakes us. From a power standpoint the outlook for the future is not too dark for optimism.

We turn now to an interesting and important fact, one highly significant to the history of anthropology: The thesis set forth in the preceding pages is substantially the same as that advanced by Lewis H. Morgan and E. B. Tylor many decades ago. We have expounded it in somewhat different form and words; our presentation is, perhaps, more systematic and explicit. At one point we have made a significant change in their theoretical scheme: we begin the third great stage of cultural evolution with engines rather than with writing. But essentially our thesis is that of the Evolutionist school as typified by Morgan and Tylor.

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[22] Herbert L. Anderson, *Progress in Harnessing Power from Uranium* (Scientific Monthly, June, 1940).

[23] Robert D. Potter, *Is Atomic Power at Hand?* (Scientific Monthly, June, 1940), p. 573.

[24] *Fast New World* (Collier's, July 6, 1940).

[25] See C. C. Abbot, *Utilizing Heat from the Sun* (Smithsonian Miscellaneous Collections, Vol. 98, No. 5, March 30, 1939).

According to Morgan, culture developed as man extended and improved his control over his environment, especially with regard to the food supply. The "procurement of subsistence" is man's "primary need" (p. 525).[26]

> The important fact that mankind commenced at the bottom of the scale and worked up, is revealed in an expressive manner by their successive arts of subsistence. Upon their skill in this direction, the whole question of human supremacy on the earth depended. Mankind are the only beings who may be said to have gained an absolute control over the production of food; which at the outset they did not possess above other animals. Without enlarging the basis of subsistence, mankind could not have propagated themselves into other areas not possessing the same kinds of food, and ultimately over the whole surface of the earth; and, lastly, without obtaining an absolute control over both its variety and amount, they could not have multiplied into populous nations. It is accordingly probable that the great epochs of human progress have been identified, more or less directly, with the enlargement of the sources of subsistence (p. 19).
>
> When the great discovery was made that the wild horse, cow, sheep, ass, sow and goat might be tamed, and, when produced in flocks and herds, become a source of permanent subsistence, it must have given a powerful impulse to human progress (p. 534).

And

> the acquisition of farinaceous food by cultivation must be regarded as one of the greatest events in human experience (p. 42).

Morgan is much concerned with the significance of technology and its development:

"The domestic animals supplementing human muscle with animal power, contributed a new factor of the highest value" (p. 26). The bow and arrow, "the first deadly weapon for the hunt, . . . must have given a powerful upward influence to ancient society," since it made man more effective in the food quest (pp. 21–22). "The plow drawn by animal power may be regarded as inaugurating a new art" (p. 26). The "production of iron gave the plow with an iron point and a better spade and axe" (p. 26). Many other inventions, such as pottery, adobe brick, metallurgy—when man "had invented the furnace, and produced iron from ore, nine tenths of the battle for civilization was won" (p. 43)—are emphasized as motive forces of cultural development. "The most advanced portion of the human race were halted, so to express it, at certain stages of progress, until some great invention or discovery, such as the domestication of animals or the smelting of iron ore, gave a new and powerful impulse forward" (pp. 39–40).

Morgan shows how technological advance brings about social change: technological evolution produces social evolution. In many places, but particularly in Part IV of *Ancient Society*, he shows how property, which accumu-

[26] The page references are to Morgan's *Ancient Society*, Henry Holt edition.

lates through "an enlargement of the means of subsistence' and through a development of the industrial arts, affects and changes the constitution of society. "Property and office were the foundations upon which aristocracy planted itself" (p. 551). Also,

> From . . . the increased abundance of subsistence through field agriculture, nations began to develop, numbering many thousands under one government . . . The localization of tribes in fixed areas and in fortified cities, with the increase of the numbers of the people, intensified the struggle for the possession of the most desirable territories. It tended to advance the art of war, and to increase the rewards of individual prowess. These changes of condition and of the plan of life indicate the approach of civilization which was to overthrow gentile and establish political society (p. 540).

We find essentially the same ideas in Tylor. Like Morgan, Tylor declares that man's "first need is to get his daily food" (p. 206).[27] Culture develops as man's control over his environment, especially over the food supply, increases. Mankind advanced from savagery to barbarism when they took to agriculture: "With the certain supply of food which can be stored until next harvest, settled village and town life is established, with immense results in the improvement of arts, knowledge, manners and government" (p. 24). "Those edible grasses," says Tylor, "which have been raised by cultivation into the cereals, such as wheat, barley, rye, and by their regular and plentiful supply have become the mainstay of human life and *the great moving power of civilization*" (p. 215; emphasis ours).

A pastoral economy, according to Tylor, is superior to that of a hunting-and-gathering (wild food) economy, but inferior to an agricultural economy. A combination of agriculture and animal husbandry is superior to either way of life by itself (pp. 24, 220).

Social evolution comes as a consequence of technological development: To this "change of habit [i.e., from a wild food economy to agriculture] may be plainly in great part traced the expansion of industrial arts and the creation of higher social and political institutions" (p. 118; article "Anthropology," in Encyclopedia Britannica, 11th ed.).

With the development of agriculture and the industrial arts comes a struggle for the most desirable territories (as Morgan puts it) and warfare "for gain" rather than "for quarrel or vengeance" (Tylor, p. 225). The consequences of this warfare for gain are tremendous: " . . . captives, instead of being slain, are brought back for slaves, and especially set to till the ground. By this agriculture is much increased, and also a new division of society takes place . . . Thus we see how in old times the original equality of men broke up, a nation dividing into an aristocracy of warlike freemen, and an inferior laboring caste" (p. 225). "It was through slave labor that agriculture and

[27] Page references are to Tylor's *Anthropology* (New York, Appleton & Co. edition of 1916).

industry increased, that wealth accumulated, and leisure was given to priests, scribes, poets, philosophers, to raise the level of men's minds" (p. 435). Furthermore, according to Tylor, warfare, among culturally advanced peoples, produces "two of the greatest facts in history—the organised army . . . and the confederation of tribes . . ." (pp. 432–433); tribes become states, primitive society gives way to civil society.

Tylor is much interested in the ways in which man harnesses the forces of nature and the extent to which energy is harnessed. "It was a great movement in civilization," he says, when man harnessed water power (p. 204). He speaks of the "civilized world . . . drawing an immense supply of power from a new source, the coal burnt in the furnace of the steam-engine, which is already used so wastefully that economists are uneasily calculating how long this stored-up fossil force will last, and what must be turned to next—tide force or sun's heat—to labor for us" (pp. 204–205).

Tylor clearly recognizes the problem we have dealt with in this essay when he speculates: "It is an interesting problem in political economy to reckon the means of subsistence in our country during the agricultural and pastoral period, and to compare them with the resources we now gain from coal, in doing home-work and manufacturing goods to exchange for foreign produce. Perhaps the best means of realizing what coal is to us, will be to consider, that of three Englishmen now [1881], one at least may be reckoned to live by coal, inasmuch as without it the population would have been so much less" (p. 272). The energy significance of modern civilization lies in the fact that "in modern times, man seeks more and more to change the laborer's part he played in early ages, for the higher duty of director or controller of the world's forces" (p. 205).

Thus, we see that our essay is substantially a systematic exposition of the ideas of Morgan and Tylor. Man is an animal. His first and greatest need is food. Control over habitat in general and food supply in particular is effected by means of tools (of all kinds, weapons included). Through invention and discovery the technological means of control are extended and improved. Social evolution follows upon technological evolution.

At one point we have made an innovation. Both Morgan (p. 12) and Tylor (p. 24) use the origin of writing to mark the beginning of the third great era of cultural development, "Civilization." In our scheme, "civilization" begins with the invention of the steam engine as a practical means of harnessing energy.

Although Morgan and Tylor both deal directly with the energy factor in cultural development, they lose sight of it when they consider writing. Writing is not a motive force. What change would writing have effected in the culture of the Arunta, or the Eskimo, or the Iroquois? It would not have altered their way of life in any essential respect. The culture of the ancient Peruvians,

which lacked writing, was quite as advanced as that of the Aztecs who had writing. And in our own culture, writing has served to preserve and perpetuate —when it has not sanctified—the ignorance and superstitions of our barbaric ancestors quite as much as it has promoted progress and enlightenment.

But, if writing is not to be considered a motive force in cultural development, the human organism, domesticated animals, cultivated plants, water wheels, windmills, steam engines, etc., are motive forces (or the means of harnessing energy). What we have done is to reduce all specific, concrete motive forces in cultural development to a single, abstract, common term: energy. To classify cultures as "wild food, domestic food, and literate," as Morgan and Tylor did, is illogical; it is like classifying vehicles as "three-wheeled, four-wheeled, and pretty." We classify cultures according to the way, or ways, in which they harness energy and the manner in which it is put to work to serve human needs.

In the foregoing we have, we believe, a sound and illuminating theory of cultural evolution. We have hold of principles, fundamental principles, which are operative in all cultures at all times and places. The motive force of cultural evolution is laid bare, the mechanisms of development made clear. The nature of the relationship between social institutions on the one hand and technological instruments on the other is indicated. Understanding that the function of culture is to serve the needs of man, we find that we have an objective criterion for evaluating culture in terms of the extent to which, and the efficiency with which, human needs are satisfied by cultural means. We can measure the amounts of energy expended; we can calculate the efficiency of the expenditure of energy in terms of measurable quantities of goods and services produced. And, finally, as we see, these measurements can be expressed in mathematical terms.

The theory set forth in the preceding pages was, as we have made clear, held by the foremost thinkers of the Evolutionist school of the nineteenth century, both in England and in America. Today they seem to us as sound as they did to Tylor and Morgan, and, if anything, more obvious. It seems almost incredible that anthropologists of the twentieth century could have turned their backs upon and repudiated such a simple, sound, and illuminating generalization, one that makes the vast range of tens of thousands of years of culture history intelligible. But they have done just this.[28] The anti-evolutionists, led in America by Franz Boas, have rejected the theory of evolution in cultural anthropology—and have given us instead a philosophy of "planless hodge-podge-ism."

[28] One distinguished anthropologist has gone so far as to declare that "the theory of cultural evolution [is] to my mind the most inane, sterile, and pernicious theory ever conceived in the history of science . . . " B. Laufer, in a review of Lowie's *Culture and Ethnology* (AMERICAN ANTHROPOLOGIST, Vol. 20, 1918), p. 90.

It is not surprising, therefore, to find at the present time the most impressive recognition of the significance of technological progress in cultural evolution in the writings of a distinguished physicist, the Nobel prize winner, Robert A. Millikan:[29]

The changes that have occurred within the past hundred years not only in the external conditions under which the average man, at least in this western world, passes life on earth, but in his superstitions . . . his fundamental beliefs, in his philosophy, in his conception of religion, in his whole world outlook, are probably greater than those that occurred during the preceding four thousand years all put together. Life seems to remain static for thousands of years and then to shoot forward with amazing speed. The last century has been one of those periods of extraordinary change, the most amazing in human history. If, then, you ask me to put into one sentence the cause of that recent rapid and enormous change I should reply: "It is found in the discovery and utilization of the means by which heat energy can be made to do man's work for him."

Tucked away in the pages of Volume II of a manual on European archeology, too, we find a similar expression from a distinguished American scholar, George G. MacCurdy:[30]

The *degree of civilization* of any epoch, people, or group of peoples *is measured by ability to utilize energy for human advancement or needs.* Energy is of two kinds, internal and external or free. Internal energy is that of the human body or machine, and its basis is food. External energy is that outside the human body and its basis is fuel. Man has been able to tap the great storehouse of external energy. Through his internal energy and that acquired from external sources, he has been able to overcome the opposing energy of his natural environment. *The difference between these two opposing forces is the gauge of civilization* (emphasis ours).

Thus, this view is not wholly absent in anthropological theory in America today although extremely rare and lightly regarded. The time will come, we may confidently expect, when the theory of evolution will again prevail in the science of culture as it has in the biological and the physical sciences. It is a significant fact that in cultural anthropology alone among the sciences is a philosophy of anti-evolutionism respectable—a fact we would do well to ponder.

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[29] *Op. cit.*, p. 211.

[30] *Human Origins* (New York, 1933), Vol. II, pp. 134–135.