10 Energy and the Evolution of Culture

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> The degree of civilization of any epoch, people, or group of peoples, is measured by ability to utilize energy for human advancement or needs.
>
> George Grant MacCurdy, *Human Origins*[1]

> the history of civilization becomes the history of man's advancing control over energy.
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> Wilhelm Ostwald, *The Modern Theory of Energetics*[1]

Having examined the culture process in a number of its aspects, we now turn to a consideration of it as a whole.

As we have already seen, "culture" is the name of a distinct order, or class, of phenomena, namely, those things and events that are dependent upon the exercise of a mental ability, peculiar to the human species, that we have termed "symbolling." To be more specific, culture consists of material objects – tools, utensils, ornaments, amulets, etc. – acts, beliefs, and attitudes that function in contexts characterized by symbolling. It is an elaborate mechanism, an organization of exosomatic ways and means employed by a particular animal species, man, in the struggle for existence and survival.

One of the significant attributes of culture is its transmissibility by non-biological means. Culture in all its aspects, material, social, and ideological, is easily and readily transmitted from one individual, one generation, one age, one people, or one region, to another by social mechanisms. Culture is, so to speak, a form of social heredity. We thus view culture as a continuum, a suprabiological, extra-somatic order of things and events, that flows down through time from one age to the next.

We have seen also, in preceding chapters, that since culture constitutes a distinct order of phenomena, it can be described and interpreted in terms of principles and laws of its own. Cultural elements act and react upon one another in their own way. We can discover the principles of behavior of various sub-classes of cultural elements and of cultural systems as a whole; and we can formulate the *laws* of cultural phenomena and systems.

We now propose to sketch the evolution of culture from its beginning upon an anthropoid level to the present time. We may regard the human race – man – as a one. We may likewise think of all of the various cultures, or cultural traditions, as constituting a single entity: the culture of mankind. We may, therefore, address ourselves to the task of tracing the course of the development of this culture from its source to the present day.

Let us return for a moment to a further consideration of the structure and function of the organization of things and processes, the *system*, that we

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call culture. Culture is an organized, integrated system. But we may distinguish subdivisions within, or aspects of, this system. For our purpose, we shall distinguish three subsystems of culture, namely, technological, sociological, and ideological systems. The technological system is composed of the material, mechanical, physical, and chemical instruments, together with the techniques of their use, by means of which man, as an animal species, is articulated with his natural habitat. Here we find the tools of production, the means of subsistence, the materials of shelter, the instruments of offense and defense. The sociological system is made up of interpersonal relations expressed in patterns of behavior, collective as well as individual. In this category we find social, kinship, economic, ethical, political, military, ecclesiastical, occupational and professional, recreational, etc., systems. The ideological system is composed of ideas, beliefs, knowledge, expressed in articulate speech or other symbolic form. Mythologies and theologies, legend, literature, philosophy, science, folk wisdom and common sense knowledge, make up this category.

These three categories comprise the system of culture as a whole. They are, of course, interrelated; each reacts upon the others and is affected by them in turn. But the influence of this mutual interaction is not equal in all directions. The roles played by the several sub-systems in the culture process as a whole are not equal by any means. The primary role is played by the technological system. This is, of course, as we would expect it to be; it could not be otherwise. Man as an animal species, and consequently culture as a whole, is dependent upon the material, mechanical means of adjustment to the natural environment. Man must have food. He must be protected from the elements. And he must defend himself from his enemies. These three things he must do if he is to continue to live, and these objectives are attained only by technological means. The technological system is therefore both primary and basic in importance; all human life and culture rest and depend upon it.

Social systems are in a very real sense secondary and subsidiary to technological systems. In fact a social system may be defined realistically as the organized effort of human beings in the use of the instruments of subsistence, offense and defense, and protection. A social system is a function of a technological system. A ship, says Childe, "and the tools employed in its production symbolize a whole economic system." The technology is the independent variable, the social system the dependent variable. Social systems are therefore determined by systems of technology; as the latter change, so do the former. "The bronze axe which replaces . . . [the stone axe]," again to quote Childe, "is not only a superior implement, it also presupposes a more complex economic and social structure."[2]

Ideological, or philosophical, systems are organizations of beliefs in which human experience finds its interpretation. But experience and interpretations thereof are powerfully conditioned by technologies. There is a type of philosophy proper to every type of technology. The interpretation of a system of experience in which a *coup de poing* is a characteristic feature will, as it must, reflect this kind of experience. It would not be improper to speak of a *coup de poing* type of philosophy as well as of technology. A pastoral, agricultural, metallurgical, industrial, or military technology will each find its corresponding expression in philosophy. One type of technology will find expression in the philosophy of totemism, another in astrology or quantum mechanics.

But experience of the external world is not felt and interpreted merely at the point of technological articulation; it is filtered through the prism of social systems also. The qualities and features of social, political, ecclesiastical, economic, military, etc., systems are therefore reflected in philosophies.

We may view a cultural system as a series of three horizontal strata: the technological layer on the bottom, the philosophical on the top, the sociological stratum in between. These positions express their respective roles in the culture process. The technological system is basic and primary. Social systems are functions of technologies; and philosophies express technological forces and reflect social systems. The technological factor is therefore *the* determinant of a cultural system as a whole. It determines the form of social systems, and technology and society together determine the content and orientation of philosophy. This is not to say, of course, that social systems do not condition the operation of technologies, or that social and technological systems are not affected by philosophies. They do and are. But to condition is one thing; to determine, quite another.

We are now in possession of a key to an understanding of the growth and development of culture: technology. A human being is a material body; the species, a material system. The planet earth is a material body; the cosmos, a material system. Technology is the mechanical means of articulation of these two material systems, man and cosmos. But these systems are dynamic, not static; energy as well as matter is involved. Everything – the cosmos, man, culture – may be described in terms of matter and energy.

The Second Law of Thermodynamics tells us that the cosmos as a whole is breaking down structurally and running down dynamically; matter is becoming less organized and energy more uniformly diffused. But in a tiny sector of the cosmos, namely in living material systems, the direction of the cosmic process is reversed: matter becomes more highly organized and energy more concentrated. Life is a building up process. But in order to run counter to the cosmic current, biological organisms must draw upon free energy in non-living systems, capture it and put it to work in the maintenance of the vital process. All life is a struggle for free energy. Biological evolution is simply an expression of the thermodynamic process that moves in a direction opposite to that specified for the cosmos as a whole by the Second Law. It is a movement toward greater organization, greater differentiation of structure, increased specialization of function, higher levels of integration, and greater degrees of energy concentration.

From a zoological standpoint, culture is but a means of carrying on the life process of a particular species, *Homo sapiens*. It is a mechanism for providing man with subsistence, protection, offense and defense, social regulation, cosmic adjustment, and recreation. But to serve these needs of man energy is required. It becomes the primary function of culture, therefore, to harness and control energy so that it may be put to work in man's service. Culture thus confronts us as an elaborate thermodynamic, mechanical system. By means of technological instruments energy is harnessed and put to work. Social and philosophic systems are both adjuncts and expressions of this technologic process. The functioning of culture as a whole therefore rests upon and is determined by the amount of energy harnessed and by the way in which it is put to work.[3]

But "the way in which it is put to work" introduces another factor besides energy. Energy by itself is meaningless. To be significant in cultural systems, energy must be harnessed, directed, and controlled. This is of course accomplished by technological means, by means of tools of one kind or another. The efficiency of technological means varies; some are better than others. The amount of food, clothing, or other goods produced by the expenditure of a given amount of energy will be proportional to the efficiency of the technological means with which the energy is put to work, other factors remaining constant.

We may therefore distinguish three factors in any cultural situation or system: (1) the amount of energy harnessed per capita per year; (2) the efficiency of the technological means with which energy is harnessed and put to work; and, (3) the magnitude of human need-serving goods and services produced. Assuming the factor of habitat to be a constant, the degree of cultural development, measured in terms of amount of human need-serving goods and services produced per capita, is determined by the amount of energy harnessed per capita and by the efficiency of the technological means with which it is put to work. We may express this concisely and succinctly with the following formula: $E \times T \rightarrow C$, in which C represents the degree of cultural development, E the amount of energy harnessed per capita per year, and T, the quality or efficiency of the tools employed in the expenditure of the energy. We can now formulate the basic law of cultural evolution: Other factors remaining constant, *culture evolves as the amount of energy harnessed per capita per year is increased, or as the efficiency of the instrumental means of putting the energy to work is increased.* Both factors may increase simultaneously of course. We may now sketch the history of cultural development from this standpoint.

If culture is a mechanism for harnessing energy, it must find this energy somewhere; it must lay hold of natural forces in some form or other if they are to be put to work in the service of man's needs. The first source of energy exploited by the earliest cultural systems was, of course, the energy of the human organism itself. The original cultures were activated by human energy and by this source and form alone. The amount of power that an average adult man can generate is small, about

1/10th of one horsepower. When women and children, the sick, aged, and feeble are considered, the average power resources of the earliest cultural systems might be reckoned at about 1/20th horsepower per capita. Since the degree of cultural development – the amount of human need-serving goods and services produced per capita – is proportional to the amount of energy harnessed and put to work per capita per year, other factors remaining constant, these earliest cultures of mankind, dependent as they were upon the meager energy resources of the human body, were simple, meager, and crude, as indeed they had to be. No cultural system, activated by human energy alone, can develop very far. Some progress can of course be made by increasing the efficiency of the technological means of putting energy to work, but there is a limit to the extent of cultural advance on this basis. We can form a realistic picture of cultural development within the limits of human energy resources by looking at such modern cultures as those of the Tasmanians, Fuegians, or Andamanese; or the Paleolithic cultures of Europe.

If culture is to advance beyond the limits of maximum technological efficiency and the energy resources of the human body, it must devise new ways to harness additional amounts of energy by tapping natural resources in some new form. In some preliterate cultural systems, fire, wind or water was exploited as a source of energy, but only occasionally and to a very insignificant extent. The conquest of fire was a very early cultural achievement, but it was not until the invention of a practical steam engine that fire became important as a form of energy. Fire was important in early cultures in cooking, providing warmth, frightening wild beasts, and as a symbol, but not as a form of energy. In more advanced cultures, fire was important or essential in the ceramic and metallurgical arts, but here also it is not functioning as a form of energy: i.e., we cannot equate, or substitute, muscle power for fire in any of these contexts. There is one context, however, in which fire functions as energy in some primitive cultures: in hollowing out tree trunks in the manufacture of dugout canoes. Here fire is substituted for muscle power. And there may be a few more similar uses of fire. But, all in all, prior to the invention of the steam engine in modern times, cultural systems made very little use of fire as a form and source of energy which could be substituted for human muscle power.

Primitive peoples could float freight down a flowing stream, but until the invention of the water wheel shortly before the beginning of the Christian era, there was no other way in which moving water could be used as a source of energy for culture building. Wind was not employed as a source of energy until comparatively recent times, and it never has been an important source of power.

Thus, we see that fire, water and wind were utilized as sources of energy only to a very limited and insignificant extent during the first hundreds of thousands of years of culture history. But there is still another source of energy that was available to primitive man, and eventually we find his cultural systems harnessing it: the energy of plants and animals.

Plants are, of course, forms and magnitudes of energy. Energy from the sun is captured by the process of photosynthesis and stored up in the form of plant tissue. All animal life is dependent, in the last analysis, upon this solar energy stored up in plants. All life, therefore, is dependent upon photosynthesis.

The first men subsisted upon plants and animals as, of course, their pre-human ancestors did before them. The earliest culture systems developed techniques of hunting, fishing, trapping, collecting, gathering, etc., as means of exploiting the plant and animal resources of nature. But merely appropriating natural resources is one thing; harnessing and controlling them is quite another. After some 985,000 years of cultural development, certain plants were brought under the control of domestication and cultivation, and various animal species were brought under control through domestication. The energy resources for culture building were greatly increased as a consequence of this increase in control over the forces of nature. The yield of plant food and other useful plant materials per unit of human labor was greatly increased by the substitution of plant cultivation for wild plant gathering. Improved strains were developed through selective breeding. Cultivation, fertilization and irrigation served to increase the yield per unit of human energy, or labor. Among the plants brought under cultivation, the cereals have been especially important. Tylor has called them "the great moving power of civilization." All of the great civilizations of antiquity were brought into being by the cultivation of cereals; no great culture has ever been achieved independently of the cultivation of cereals.

The domestication of animals, too, increased the energy resources for culture building as a consequence of the increase in control over these forms of energy. Their yield in food and other useful animal products per unit of human labor was greatly increased by the substitution of domestication for hunting. In a hunting economy animals had to be killed before they could be used, and when they were consumed more had to be found and killed. By means of domestication a people could subsist upon its herds and flocks without diminishing their numbers at all; they could even be increased. Animals, like plants, were improved through selective breeding, and, in addition to supplying milk, meat, wool, and hides, some species could be used as motive power, either to carry burdens or to draw plows or vehicles. The domestication of animals thus greatly increased the amount of energy under cultural control and available for culture building.

A great advance in cultural development would be expected, therefore, as a consequence of the great increase in the amount of energy harnessed and controlled per capita per year by means of the agricultural and pastoral arts. And this is exactly what took place. The archeological record bears out our theory fully at this point. In a few thousand years after the inauguration of the arts of domestication and cultivation, the great civilizations of antiquity, of Egypt, Mesopotamia, India, China, and, in the New World, in Mexico, Middle America, and the Andean Highlands, came quickly into being. After hundreds of thousands of years of relatively slow and meager development during the Old Stone Ages, culture suddenly shot forward under the impetus of augmented energy resources achieved by agriculture and animal husbandry. Great cities, nations, and empires took the place of villages, tribes, and confederacies as a consequence of the Agricultural Revolution. Rapid progress was made, especially in the Old World, in all of the arts – industrial, esthetic and intellectual. Great engineering projects were undertaken and executed; huge architectural edifices erected. The ceramic, textile and metallurgical arts expanded and flourished. Astronomy, writing, and mathematics were developed. Beginnings were made in a rational science of medicine. Impressive works of art were produced, in relief, sculpture, and even in painting. Development and progress took place in all aspects of culture.

But culture did not advance continuously and indefinitely as a consequence of increased energy resources won by the techniques of agriculture and animal husbandry. After a period of rapid growth, the upward curve of progress levelled off onto a plateau. The peaks of cultural development in Egypt, Mesopotamia, India, and China were reached prior to 1000 B.C., in some cases considerably earlier, and from that time until the beginning of the Fuel Age, about A.D. 1800, no culture of the Old World surpassed, in any profound and comprehensive way, the highest levels achieved in the Bronze Age. This is not to say, of course, that there was no progress at all from 1,000 B.C. to A.D. 1789. There were innovations here and there and many refinements of already existing traits. But, taking cultures as wholes, and measuring them by such yardsticks as size of political unit, size of city, magnitude of architectural edifices and engineering works, density of population, production and accumulation of wealth, etc., the cultures of Europe between the disintegration of the Roman Empire and the rise of the Power Age were in general inferior to those of the ancient oriental civilizations. The reason why cultures did not continue indefinitely to advance under the impetus of an agricultural and stockraising technology is a matter that we shall consider presently.

It appears then that culture had developed about as far as it could on an agricultural and animal husbandry basis before the beginning of the Christian era, at least in the Old World; the New World lagged somewhat behind. And it is reasonable to suppose that culture never would have exceeded the peaks already achieved by this time had not some way been devised to harness additional amounts of energy per capita per year by tapping the forces of nature in a new form. A way was found, however, to do this: energy in the form of coal, and, later, oil and gas, was harnessed by means of steam and internal combustion engines. By tapping the vast deposits of coal, oil and natural gas, a tremendous increase in the amount of energy available for culture building was quickly effected. The consequences of the Fuel Revolution were in general much like those of the Agricultural Revolution: an

increase in population, larger political units, bigger cities, an accumulation of wealth, a rapid development of the arts and sciences, in short, a rapid and extensive advance of culture as a whole.

But, again, after a very rapid rise, the curve of cultural development began to show some signs of levelling off. We do not wish to intimate that culture had already gone as far as it could on a Fuel basis, for we do not believe it had; we merely believe that we can detect signs of a slowing down of the advance. But before the question of how far cultural development *could* advance on a Fuel-Agricultural-Animal-Husbandry-Human-Energy basis could become anything like a matter of immediate concern, a tremendously significant technological event took place: the energy resources of atomic nuclei were harnessed. For the first time in culture history energy in a form other than solar had been harnessed. No cultural advance has as yet been effected by the utilization of this new form of energy as a source of industrial power. And before it becomes significant in this respect, another fateful question will have to be met and answered, namely, the consequences of the use of atomic energy in warfare.

Thus we trace the development of culture from anthropoid levels to the present time as a consequence of periodic increases in the amount of energy harnessed per capita per year effected by tapping new sources of power. There is, however, another technological factor involved which we have merely mentioned incidentally so far; we must now consider it more fully, namely, the role of tools in the culture process.

Energy is of course neither created nor annihilated, at least not within cultural systems; it is merely transformed. It is harnessed and it is put to work or expended. But this requires tools and machines. The amount of energy harnessed may, and the amount of human need-serving goods produced per unit of energy does, depend upon the efficiency of the tools employed. So far, we have been holding the tool factor constant and varying the energy factor. We now hold the energy factor constant and vary that of tools. We get, then, the following generalization: *the degree of cultural development varies directly as the efficiency of the tools employed, other factors remaining constant.* If, for example, one is engaged in chopping wood, the amount chopped per unit of energy expended will vary with the efficiency of the axe; the amount will increase with the improvement of axes from the Old Stone Age, through the Neolithic, Bronze, and Iron ages up to the finest axe of alloyed steel of the present day. And so it is with other instrumental means, such as saws, looms, plows, harnesses, wheeled vehicles, boats, etc. Cultural advance is effected, therefore, by an improvement of tools as well as by increases in the amount of energy harnessed.

But the efficiency of a tool cannot be increased indefinitely; there is a point beyond which improvement of any given tool is impossible. Thus, a canoe paddle can be too long or too short, too narrow or too wide, too heavy or too light, etc. We may therefore both imagine and realize a canoe paddle of such size and shape as to make any alteration of either result in a decrease of efficiency. Similarly, we may improve bows and arrows, hoes, plows, saws, etc., up to but not beyond a certain point. Perfection, as a practical matter, is either reached or at least closely approximated. No significant improvement has been made in violins in decades. The steam locomotive has apparently come close to its limits of size and speed. To be sure, improvements may be continued for a time by the use of new materials or alloys and by the application of new mechanical principles. But even so, the improvement of any tool or machine approaches closely, if it does not reach, a limit. We cannot expect locomotives or ocean liners a mile long; they would fall apart of their own weight.

In the culture process therefore, we find that progress and development are effected by the improvement of the mechanical means with which energy is harnessed and put to work as well as by increasing the amounts of energy employed. But this does not mean that the tool and energy factors are of equal weight and significance. The energy factor is the primary and basic one; it is the prime mover, the active agent. Tools are merely the means that serve this power. The energy factor may be increased indefinitely; the efficiency of the tool only within limits. With a given amount of energy, cultural development can progress only so far: to the limits of the efficiency of the tools. When these limits have been reached, no further increases in efficiency can make up for a lack of increase in amount of energy harnessed. But increases in the amount of energy harnessed result in technological progress all along the line, in the invention of new tools and in the improvement of old ones should further improvement be possible. We see, therefore, that important though the tool factor may be, it is merely secondary to the primary and basic factor of energy. And, since increases of energy foster improvement of tools, one may say that it is energy that, at bottom, carries the culture process onward and upward. The general statement that, the environmental factor being constant, the degree of cultural development is proportional to the amount of energy harnessed per capita per year is therefore sound and illuminating.

We turn now to a consideration of social systems in the process of cultural development. A social system is, as we have seen it must be, closely related to its underlying technological system. If a people are nomadic hunters – i.e., use certain technological instruments in certain ways in order to obtain food, furs, hides, and other need-serving materials – they will have one type of social system. If they lead a sedentary life, feeding upon rich beds of shellfish, or if they are pastoralists or intensive agriculturalists, or maritime traders, or industrialists, etc., they will have other types of social systems. The process of military offense and defense and the technological means with which it is exercised also acts as a determinant of social organization, sometimes a very powerful one. Thus we see that the social system of a people is at bottom determined by the use of the technological means of subsistence and of offense and defense. Those social institutions not directly related to the technology are related indirectly; they serve to co-ordinate the various sectors of society with one another and to integrate them into a coherent whole.

The social systems of primitive peoples vary tremendously in detail because the specific circumstances of natural habitat and technology vary. But all social systems resting upon a human energy (i.e., pre-pastoral, pre-agricultural) basis belong to a common type. They are all relatively small and manifest a minimum of structural differentiation and specialization of function. We find no highly developed societies upon the primitive foundation of a technology powered by human energy alone.

The societies of pastoralists and agriculturalists in the early stages of these technological developments are likewise relatively simple, undifferentiated systems. As a matter of fact we may characterize all human social systems up to a certain point in the development of the agricultural, or farming-and-animal-husbandry, technology as *primitive* society: tribes based upon kinship ties, free access to the resources of nature for all, relatively little social differentiation and specialization, and a high degree of social equality. When, however, a certain point in the development of agriculture was reached, a profound change in social systems took place. This was the *social* aspect of the Agricultural Revolution. Let us trace the course of this social revolution in its main outlines at least.

Agriculture and animal husbandry are means of producing more food and other useful materials per unit of human energy than can be obtained by hunting, fishing, or gathering. When agriculture is combined with stock raising the energy resources for culture building are of course greater than when the cultivation of plants alone is practiced. Not only do flocks and herds supply meat, milk, wool or hides, but their muscle power may be used to carry burdens, draw plows and carts, etc. All of the great civilizations of the Old World grew up on the basis of agriculture and animal husbandry. Since, however, it is the cultivation of cereals that is the basic factor in the new agriculture-and-animal-husbandry technology, we may for the sake of brevity speak of "the social consequences of a developing agricultural technology."

As the agricultural arts developed and matured, as plants were improved through selective breeding, as new techniques of cultivation, irrigation, drainage, rotation of crops, fertilization, etc., were introduced and improved, the amount of food produced increased. As the food supply was enlarged the population increased. Small tribes grew into large tribes and these into nations and empires; villages grew into towns and towns into cities.

Not only was *more food* produced by agricultural techniques than by hunting, fishing, and gathering, but more food per capita, more per unit of human labor expended. And, as the agricultural arts developed, the productivity of human labor in this field increased. It gradually became possible for a portion of the population to produce food for all. This meant that a portion of the population could be diverted from agriculture and turned into other channels, such as the industrial and esthetic arts.

As the agricultural technology advanced, more and more of the population could thus be withdrawn from the fields and put to work at other tasks and occupations. Society thus became divided along occupational lines, differentiated structurally and specialized functionally. This led to further social developments as we shall see in a moment.

The mere increase in population had important consequences in another direction also. Tribes and clans were organized upon a basis of kinship ties; social relations were largely exercised in this form. This mechanism worked very well as long as the social units were relatively small; a clan or tribe could be effective as a mechanism of social organization and intercourse as long as its members were not exceedingly numerous, as long as social relations could be *personal*. But when, under the impetus of a developing agricultural technology and an increasing food supply, clan and tribal units grew to huge size, they tended to fall apart of their own weight. Primitive society tended therefore to disintegrate as a consequence of sheer increase of numbers. A new type of social organization was therefore required if chaos was to be averted. This new organization was found in the State. This was another consequence of the Agricultural Revolution.

The developing agricultural technology brought about a profound change in economic organization, also. In tribal society production, exchange, and consumption of wealth took place upon a personal, kinship basis; the economic organization was virtually identified with the kinship system. This type of economic organization worked well in a small society with a minimum of division of labor and with little differentiation of social structure along occupational lines. But as society became extensively differentiated, as a consequence of the increase in productivity of human labor in agriculture, a new type of economic system was required; a way of relating *classes* economically to one another must be devised. This can be done either in a feudal or a monetary-market system. In either case, however, we have a system in which property relations form the basis of social relations rather than the reverse, as was the case in tribal, kinship, society.

On preliterate cultural levels there was of course some fighting between tribal groups. Competition for favored hunting and fishing grounds or other natural resources, vengeance for real or fancied (e.g., magical) injuries, led to a certain amount of inter-tribal conflict. But the factors necessary for large scale and systematic and sustained warfare were lacking. These were supplied, however, as a consequence of the Agricultural Revolution. A high degree of development of the agricultural, metallurgical, ceramic, and other arts resulted in the production and accumulation of vast amounts of wealth. A rich nation's possessions together with the natural and human resources that made the wealth possible would constitute a rich prize to any people who could conquer it. Warfare became a profitable occupation. Thus we find, especially in Mesopotamia, a condition of almost chronic warfare: nations contending with one another for rich, fertile river valleys, the treasures of palace and temple, one nation conquering and looting another, new empires rising upon the ruins of old.

The social consequences of systematic and chronic warfare are significant: the formation of a professional military class, which in collaboration with political rulers and sometimes even autonomously, may become a powerful political force; the reduction of peoples of conquered nations to the status of slavery or serfdom; and the subordination of the masses at home to the imperatives of prolonged military conflict. Thus warfare tended powerfully to divide society into two major social classes: a relatively small ruling group who organized and directed the campaigns and to whom the overwhelming proportion of the wealth taken as booty went, and a large class who provided the "sinews of war" – the peasants, serfs, the common soldiers, etc. There was often but little difference between the lot of the masses at home and that of the masses of the vanquished nation after conquest and subjugation had been accomplished.

Warfare was not, however, the only means, or social process, that operated to divide societies of the post-Agricultural Revolutionary era into a small, wealthy, powerful, ruling class on the one hand, and a large class of peasants, serfs, or slaves on the other. The peaceful process of commerce, and especially the use of money, operated also to bring about the same end. Trade and commerce are means of concentrating wealth. In this competitive process the big merchants grew at the expense of the small ones. Wealth tended to gravitate into a few hands. Money lending is a particularly rapid and effective means of making the poor poorer and the wealthy richer. When interest rates range from say thirty to one hundred percent or even more, as they did in ancient times, the small borrowers rapidly sink into economic bondage to the money-lenders. It was not at all uncommon in Greece before the reforms of Solon or Kleisthenes for a small farmer to sell his children into slavery in order to pay merely the interest on his loan, let alone the principal. Taxes levied by the ruling class through the mechanism of the state and exorbitant rents levied upon small tenants by large landlords also tended to reduce the masses to a condition of economic bondage and impotence.

Thus we see that the social, political and economic effects of the technological revolution in agriculture were: the dissolution of the old social system of primitive society, the obsolescence of tribe and clan; the division of society into various occupational groups – guilds of artisans and craftsmen; the division of society horizontally into two major classes: a small, powerful, wealthy, ruling class and a large class, governed and exploited by the ruling class and held in bondage in one form or another by them. Civil society based upon property relations took the place of primitive society based upon kinship; the State replaced tribe and clan. The technological revolution in agriculture precipitated and carried through a revolution in the social, political, and economic sectors of culture. As the amount of energy harnessed and put to work per capita per year was increased by the development of the agricultural technology, society became more and more differentiated structurally and increasingly specialized functionally. Concomitant with this trend was the emergence of a special social mechanism of co-ordination of functions and correlation of structures, a mechanism of integration and regulation. This political mechanism had two aspects, secular and ecclesiastic, sometimes closely related, sometimes distinct, but always present. We call this special mechanism of co-ordination, integration and regulation the State-Church. The evolution of civil society from the early metallurgical era to the present day, passing through a variety of forms of the state and class relations, is a story that we shall turn to presently. At this point we wish to return to a matter touched upon earlier.

If culture evolves when and as the amount of energy harnessed per capita per year increases, why did not culture continue to advance indefinitely as a consequence of the technological revolution in agriculture? As we have already seen, it did not. On the contrary, after attaining certain levels it ceased to advance and thereafter continued on a plateau until a new and powerful impetus came from the Fuel Revolution. Yet, agriculture as a technological process, as a mechanism of harnessing solar energy, was not developed to its technological limits by any means; it has not even yet reached those limits or even approached them very closely according to agronomists. Why, then, did technological progress in agriculture eventually slow down and virtually stop after so rapid a rise?

The answer seems to lie in the relationship between socioeconomic system and technological system established by the Agricultural Revolution. As we have noted, every social system rests upon and is determined by a technological system. But every technological system functions *within* a social system and is therefore *conditioned* by it. The social system created by the Agricultural Revolution affected the technological process so as eventually to "contain it" and to bring further progress in culture as a whole virtually to a standstill. This is how it was done.

The social system of civil society was, as we have seen, divided into a ruling class and an exploited class. The latter produced the wealth; the former appropriated so large a portion of it as to leave the latter with but minimum means of subsistence. No advantage would accrue to the producing class if they enlarged their production through increased efficiency; the increment would only be appropriated by the ruling class. On the other hand, the ruling class were not likely to resort to a long range plan to improve the techniques of agricultural production. If they needed more than they were obtaining at the moment the need was immediate and a long range plan would have been of no use. They would therefore resort to greater exactions from the producing class. But in many, if not most, instances, it would seem, the ruling class had ample for their needs. As a matter of fact, a great deal of evidence indicates that one of the problems they had to contend with was that of overproduction rather than of insufficiency. Thus we see, especially in Egypt but also in Mesopotamia and elsewhere, the ruling class engaging in "conspicuous waste and consumption"

and that on a grand scale. Palaces and temples were loaded with wealth and vast treasures were deposited with the dead in tombs. In addition to this, great public works programs – pyramids, monuments, temples, tombs and palaces – were continually being built. It would appear that the ruling class was frequently confronted with the problem of overproduction and the threat of technological unemployment or a surplus of population among the lower classes. Their great public works programs, the wholesale disposition of wealth in mortuary customs, etc., enabled them to solve both these problems with one stroke. Thus the social system tended to act as a damper on further increase in technological progress once a certain stage of development had been reached. In addition to the factors mentioned above, Childe has pointed out that the social system operated not only to concentrate wealth in the hands of the ruling minority but effectively prevented the fruits of technological progress from being distributed among the masses of the population. There was, consequently, no chance for the technology of production to expand quantitatively or to improve qualitatively.

We see, then, that the new agricultural technology resulted in a tremendous growth of culture in its initial stages. But in effecting this advance a social system was created that eventually curbed and contained the technological system in such a way as to bring progress virtually to a stop, despite the fact that the *technological* limits of agricultural development had not been even closely approximated. We may reasonably conclude, therefore, that human culture would never have gone substantially beyond the peaks achieved prior to the beginning of the Christian era had not the amount of energy harnessed per capita per year been considerably enlarged by tapping the forces of nature in a new form.

The Fuel Revolution was the culmination and synthesis of a number of streams of cultural elements that had been in progress of development for some time just as the Agricultural Revolution was the organized florescence of trends of earlier ages. And, like its predecessor, the Fuel Revolution brought about great social, political and economic changes as a consequence of greatly augmenting the energy resources for culture building by harnessing solar energy in a new form, this time in coal, oil and natural gas.

As in the case of the Agricultural Revolution, the new fuel technology resulted in a great increase in population. The population of Europe prior to the Coal Age grew only from 100,000,000 in 1650 to 187,000,000 in 1800. From 1800 to 1900, however, it increased to over 400,000,000. The population of England, to cite the country in which the Industrial Revolution got under way and in which it developed to a very great extent, increased 50 percent between 1700 and 1800. But during the nineteenth century, it increased 260 percent. In the two centuries prior to 1850, the population of Japan increased but 41 percent. In the fifty years following 1872 – about the time industrialization began – however, the population increased over 80 percent. Urban development was powerfully stimulated and accelerated by the new technology as it had been by the developing agricultural technology in the Bronze Age. The European feudal system – a rural, aristocratic, agricultural production for use economy – was rendered obsolete and replaced by an urban, parliamentary, industrial, production-for-sale-at-a-profit economy. Social structure became ever more differentiated and functions more specialized. The productivity of human labor increased as technology advanced. Farm populations decreased relatively and in some instances absolutely.

Changes occurred in the class structure of society also. The basic dichotomy – a minority ruling class and the majority of the population in a position of subordination and exploitation – remained, but the composition of these classes underwent radical change. Industrial lords and financial barons replaced the landed aristocracy of feudalism as the dominant element in the ruling class, and an urban, industrial proletariat took the place of serfs, peasants, or slaves as the basic element in the subordinate class. Industrial strife took the place of peasant revolts and uprisings of slaves and serfs of earlier days. And, in a new form, the State-Church functioned as a co-ordinative and regulative mechanism to maintain the integrity of society by containing these class antagonisms and by mobilizing the resources of society for offense and defense.

We may pause at this point to take note of an interesting feature of the process of cultural evolution: *as culture evolves the rate of growth is accelerated.* As we have already seen, the rate of growth in late Neolithic and early Bronze times was much

greater than in the Paleolithic and Eolithic Ages. The Agricultural Revolution required but a few thousand years to run its course. But the Fuel Revolution is only a century and a half or two centuries old at most, and already greater changes have been effected by it perhaps than by all earlier ages put together. The change is so rapid and we are so much in the midst of it that it is difficult to grasp the situation and to realize the profound and radical nature of the revolution, social and political as well as technological, through which we are passing. Twenty-seven years ago in *New Viewpoints in American History,* Professor A. M. Schlesinger compared the culture of the United States of Lincoln's day with that of Benjamin Franklin's on the one hand, and with the culture of 1922 on the other. He remarked that the daily life with which Lincoln was familiar was in most respects like that known to George Washington and Franklin. But our culture in 1922 would have been strange and bewildering to Lincoln had he returned to the American scene:

> Buildings more than three or four stories high would be new. The plate-glass show windows of the stores, the electric street-lighting, the moving-picture theaters, the electric elevators in the buildings and especially the big department stores would be things in his day unknown. The smooth-paved streets and cement sidewalks would be new to him. The fast-moving electric street-cars and motor vehicles would fill him with wonder. Even a boy on a bicycle would be a curiosity. Entering the White House, someone would have to explain to him such commonplaces of modern life as sanitary plumbing, steam heating, friction matches, telephones, electric lights, the Victrola, and even the fountain pen. In Lincoln's day, plumbing was in its beginnings, coal-oil lamps and gas-jets were coming into use, and the steel pen had only recently superseded the quill pen. The steel rail, the steel bridge, high-powered locomotives, refrigerator cars, artificial ice, the cream separator, the twine binder, the caterpillar tractor, money orders, the parcels post, rural free delivery, the cable, the wireless, gasoline engines, repeating rifles, dynamite, submarines, airplanes – these and hundreds of other inventions now in common use were all alike unknown.[4]

But consider the changes that have taken place – in transportation, medicine, communication, and in technology in general – since Schlesinger wrote in 1922! In warfare perhaps better than in other areas of our culture, is the dizzying rate of technological progress made dramatically apparent. The technology of the first World War looks quaint today, and some of the weapons and techniques introduced for the first time in World War II are already obsolete. One hardly dares to picture the next great military conflict; novelties already unveiled and others only intimated suggest all too vividly the distance that technological progress has gone since the days of Pearl Harbor. And behind the scenes in the theater of Mars are the great research laboratories and proving grounds, working under forced draft to develop and perfect new tools and techniques in all phases of our technology. The rate of cultural advance is now greater than ever before. "Our life," wrote the distinguished physicist, Arthur Holly Compton in 1940, "differs from that of two generations ago more than American life of that day differed from the civilized life at the dawn of written history."[5] And, since Compton wrote these words, a profound and awful revolution – perhaps the most significant in all human history – has taken place: the harnessing of atomic energy.

But, even as in the case of the Agricultural Revolution and its aftermath, so in the Power Age the social system created by the new fuel technology came eventually to act as a brake upon further cultural advance. The price and profit system stimulated production and technological progress as long as the output could find a market. But, like the socio-economic system of the Bronze Age, the new commercialism of the Fuel era had its inherent limitations. No industrial nation had or could have purchasing power sufficient to keep and absorb its own output; the very basis of the industrial profit system was an excess in value of product over the cost of production in terms of wages paid to the industrial workers. Export of surplus was therefore essential; "we must export or die" is a cry of desperation heard from more than one nation in recent years. For a time new markets could be found abroad. But as the output of industrial nations increased with advances in technology, and as non-European nations such as Japan became industrialized and hence competitors for foreign markets, the international profit system began to bog down. The world market diminished as the industrial output increased. When goods could no longer be sold profitably abroad, production was curtailed at

home. Entrepreneurs are disinclined to produce goods that cannot be sold at a profit. Factories, mills and mines were closed. Millions of workers were thrown out of employment. Surplus goods were destroyed, agricultural production reduced. The awful plague of overproduction and unemployment, "starvation in the midst of plenty," settled upon the land. The social system was strangling the great technological machine of industry and paralyzing the body politic as a whole. The alternatives were stagnation and death or war and revolution. If the social system were able to contain the Fuel technology and the commercial rivalries and class conflicts engendered by it, society would become stabilized in a more or less stagnant form of industrial feudalism. Should, however, the forces inherent in the new technology be able to surmount and overcome the restrictions of the price and parliamentary system, then culture could advance toward higher levels.

There is evidence aplenty that culture, powered by the mighty forces of Fuel technology, is embarking upon the latter course. The first phase of the second great Cultural Revolution – the Industrial Revolution – has run its course and we are now entered upon the second phase, that of social, political and economic revolution. And, as in the past, war is proving to be an effective means of profound political change. The system of free and individual enterprise in business and commerce is now virtually extinct. The gold standard is merely a memory of an era that is closed. The parliamentary system of government, a device designed to permit the greatest freedom for the growth of industrial and financial enterprise, is practically obsolete also. Private right is no longer significant chiefly as a means of freedom for growth as it was in the early days of commercialism. It now leads toward competitive rivalry, internecine strife, chaos, and paralysis. Concentrations of power without public responsibility among those who own or control vast wealth, or in the ranks of organized labor, are no longer compatible with the degree of unity, integrity and strength that a nation must have if it is to compete successfully with its rivals in the international arena. The exigencies of national survival require the subordination of private right to general welfare, of part to whole. In short, the State, as the integrative and regulative mechanism of civil society, is destined to acquire ever greater power and to wield more and more control. Social evolution is moving inexorably toward higher levels of integration, toward greater concentrations of political power and control.

On the international level, too, an interesting trend of social evolution can be discerned: movement toward ever larger and larger political units. The Agricultural technology replaced villages with cities, tribes with nations and empires. The modern Fuel technology also is working toward larger political groupings, fewer concentrations of political power. The relatively recent trend toward amalgamation can be seen in the unification of Germany and Italy in the nineteenth century. The Treaty of Versailles attempted, with the "Balkanization of Europe," to oppose the age-old trend of social evolution by breaking the continent up into little pieces. One of the conspicuous and significant aspects of the Second World War in its initial phase was a movement toward the unification of Europe. A half-dozen or so World Powers engaged in the First World War; only two great powers emerged from the second. The competition for power narrows as contestants are eliminated. The logical conclusion is, however, not simply the domination of the world by a single nation – this would be but a transitional stage – but a single political organization that will embrace the entire planet and the whole human race. Toward such a denouement is our mighty Power technology rapidly moving us.

But a new and ominous element has recently entered the picture: nuclear atomic energy for military purposes. Here again the significance of this new factor derives from the fact that a new source of energy has been harnessed and in awful form. Once more we are upon the threshold of a technological revolution. But the consequences of this new technological advance may possibly differ radically from those of the Agricultural and the Fuel Revolutions. New technologies in the past have rendered old social systems obsolete but they have replaced them with new systems. The new nuclear technology however threatens to destroy civilization itself, or at least to cripple it to such an extent that it might require a century, a thousand, or ten thousand, years to regain its present status. At least this is what eminent scientists and military men tell us; as laymen we are in a child's world of ignorance, with almost all the significant facts kept beyond our reach. The destruction of a few score of centers of science and industry in Europe and the United States would just about do for Western civilization and, authorities assure us that this is well within the realm of possibility, not to say probability. The hope of the future therefore, and the salvation of mankind and civilization would seem to lie in the emergence from the next war of a *victor* – not merely a survivor – and one with sufficient power and resources to organize the whole planet and the entire human species within a single social system.

We have thus presented a sketch of the evolution of the culture of mankind from the horizon of our prehuman forebears to the present time. It is a fascinating story of adventure and progress; of a species lifting itself up by its cultural bootstraps from the status of a mere animal to a radically new way of life, a way destined to win mastery over most other species and to exert a powerful and extensive control over the natural habitat. The origin of culture elevated the evolutionary process to a new plane. No longer was it necessary for the human animal to acquire new powers and techniques through the slow process of biological change; he now had an extra-somatic mechanism of adjustment and control that could grow freely of itself. Moreover, advances in one stream of cultural development could diffuse readily to other traditions so that all might share in the progress of each. Thus the story of man becomes an account of his culture.

Technology is the hero of our piece. This is a world of rocks and rivers, sticks and steel, of sun, air and starlight, of galaxies, atoms and molecules. Man is but a particular kind of material body who must do certain things to maintain his status in a cosmic material system. The means of adjustment and control, of security and survival, are of course technological. Culture thus becomes primarily a mechanism for harnessing energy and of putting it to work in the service of man, and, secondarily, of channelling and regulating his behavior not directly concerned with subsistence and offense and defense. Social systems are therefore determined by technological systems, and philosophies and the arts express experience as it is defined by technology and refracted by social systems. Cultural systems like those of the biological level are capable of growth. That is, the power to capture any energy is also the ability to harness more and still more of it. Thus cultural systems, like biological organisms, develop, multiply, and extend themselves. The sun is the prime mover; culture, a thermodynamic system operated by it. At least, solar energy has activated all cultural systems of history up to now, and it will continue to do so after terrestrial supplies of fissionable fuels have been exhausted – if civilization should survive and reach this point. But technology is still the leading character in our play, even though it may turn out to be a villain instead of the hero. Technology builds but it may also destroy. The belief and faith that civilization, won at such great cost in pain and labor, simply cannot go down in destruction because such an end would be too monstrous and senseless, is but a naive and anthropocentric whimper. The cosmos does little know nor will it long remember what man has done here on this tiny planet. The eventual extinction of the human race – for come it will sometime – will not be the first time that a species has died out. Nor will it be an event of very great terrestrial significance.

But *man* may survive the coming holocaust of radioactivity even though his culture is tumbled to the level of Neolithic times, only to begin the long climb over again, this time perhaps by a somewhat different route; culture too may be able to profit from experience. But culture may *not* destroy or even critically wound itself with its new powers. Destruction is no more inevitable than salvation. Great though the devastation may – and will – be in the next test of strength in the international arena, the creative powers of the new technology may be sufficiently great to rise up from the ruins and to enclose the whole world in a single political embrace. Then and only then will the curse of war be lifted and the way made free and open for a fuller and richer life.

Our sketch of the evolution of culture is, it will be noted, wholly culturological. It does not resort to race, physical type, intelligence, a moral sense, the dignity of man, the spirit of progress or democracy, the individual – genius or otherwise – the rejection of the father, consciousness of kind, a set of instincts or "drives," social interaction, a basic personality structure, toilet training in infancy, or breast *vs.* bottle feeding and weaning, to account for the behavior and growth of this great extra-somatic tradition. We explain it in terms of culture itself.

A thunder-shower or a tornado is explained in terms of antecedent and concomitant meteorological events; a clan or a constitution is likewise accounted for by citing its cultural antecedents and concomitants.

Culture is, as we have pointed out repeatedly, a stream of interacting elements; one trait reacts upon others and is affected by them in return. Some elements become obsolete and are eliminated from the stream; new elements are incorporated into it. New permutations, combinations, and syntheses are continually being formed. Whether we deal with a restricted portion of the cultural continuum such as the evolution of mathematics or the genealogy of the steam engine, or whether we encompass culture in its entirety, the principle of interpretation is the same: culture grows out of culture. In our sketch of the evolution of culture as a whole we deal with large categories: technology, social systems, and philosophies. We break technology down into energy and tool factors. We observe the action of each class of elements, their impact upon others, the effect of technology upon social systems, and the influence of economic and political institutions upon agriculture and steam-driven factories. We note the role that war as a culture process has played in the course of political change. And, finally, we see the fate of civilization delicately balanced in a scales to be tipped this way or that, we know not how, by the modern miracles of nuclear technology.

Culturology is the newest venture of science. After centuries of cultivation in the fields of astronomy, physics, and chemistry; after scores of years of tillage in physiology and psychology, science has at last turned to the most immediate and powerful determinant of man's *human* behavior: his culture. After repeated trials and as many failures it was discovered that culture cannot be explained psychologically; such interpretations are merely anthropomorphisms in scientific clothing. The explanation of culture is and must be culturological. The science of culture is young but full of promise. It is destined to do great things – if only the subject of its study will continue its age-old course: onward and upward.

NOTES

1 MacCurdy, II, p. 134; Ostwald, 1907, p. 511.
2 Childe, 1936, pp. 7, 9.
3 The functioning of any particular culture will of course be conditioned by local environmental conditions. But in a consideration of culture as a whole, we may average all environments together to form a constant factor which may be excluded from our formula of cultural development.
4 Schlesinger, pp. 247–48.
5 Compton, p. 576.

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