

THE ECOSYSTEM, ENERGY, AND HUMAN VALUES

by *Howard T. Odum*

If flows of energy generate the ecosystems of the biosphere—including the phenomenon of humanity with its human values—an examination of the laws and systems of energy interaction should show how human values are related to the ecosystem's energy flows. Evaluation of energy flows may provide quantitative measures of value to help understand the role of human spiritual work in its stewardship of the earth. To help visualize energy systems, overview diagrams are presented, using a language of symbols that are at the same time mathematical formulations for computer simulations. The language is introduced and used in recent books.¹ Some of the symbols are given in figure 1. Energy diagrams may be useful for careful communication concerning comparative religion.

FLOW OF ENERGY AND THE MAXIMUM POWER PRINCIPLE

Examination of the temporal trends in ecological systems suggests that the principle of maximum power is a law that is central for explaining the systems of man and nature.² This principle says that the more lasting and hence more probable dynamic patterns of energy flow or power (including the patterns of living systems and civilizations) tend to transform and restore the greatest amount of potential energy at the fastest possible rate. For each step this requires that 50 percent of the flow from potential energy storages tends to be expanded into the pool of energy dispersion and 50 percent transformed into a new storage of energy available for a future process, one of higher quality.

Everything and anything that takes place on earth involves a flow of potential energy, provided primarily from the sun, as it streams toward a pool of dispersed or expended heat. The pathways of the stream are shaped by a hierarchy of directive forces that have evolved under nature's laws as by-products of the stream. These directive

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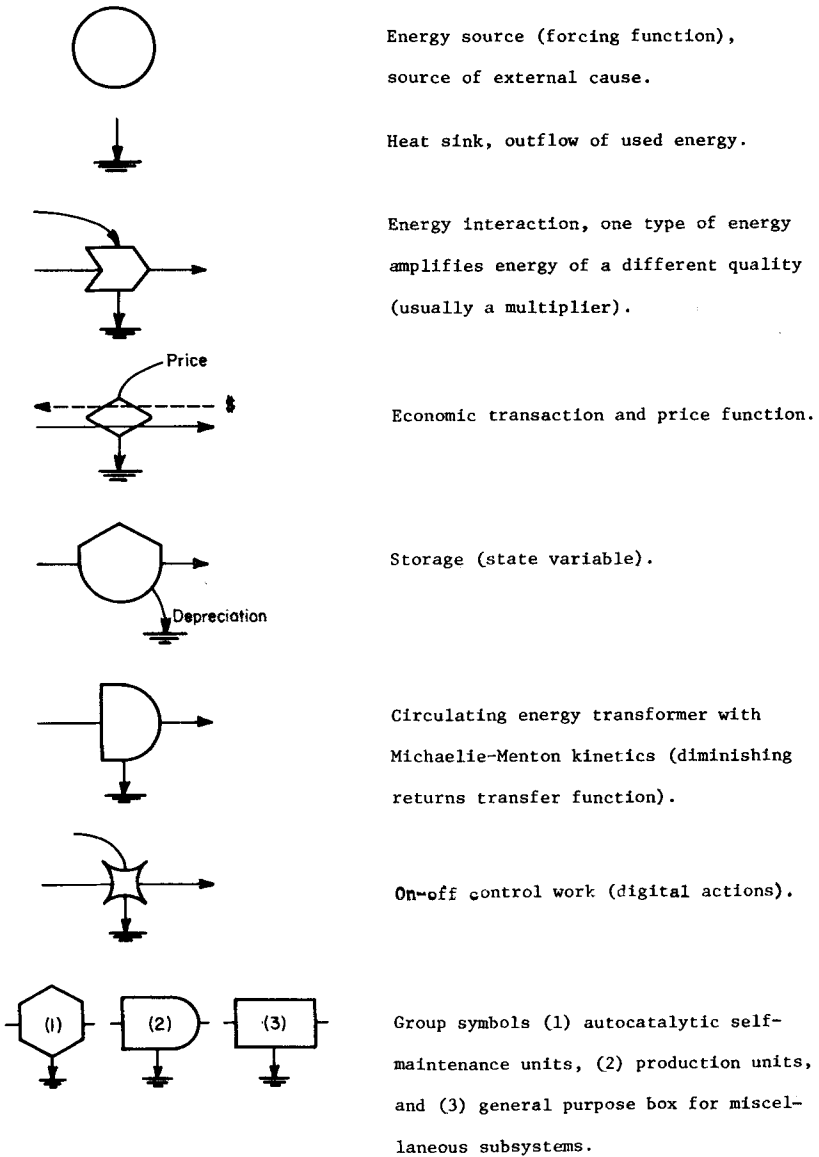


FIG. 1.—Some of the symbols of the energy circuit language

forces include wayside storages of energy in the material patterns and dynamic circulations of the earth's substances, including all the elements of the biosphere from the earliest and most primitive to the latest and most civilized or spiritual elements of human feeling, thinking, and behavior in the arts, sciences, and religions.

The principle of maximum power, which operates to shape this flow at every level, has during the past century become increasingly recognized as a primary principle of energetics; in 1922 A. J. Lotka showed that the Darwinian natural selection process logically derives from it. In recent decades it has become clear that this principle operates to shape the flow of energy even at the level of the feelings and thinking of civilized people as well as at the levels of the natural selection processes in biological and physical events.

The evolution of all events in the earth's history of thousands of millions of years is potentially explainable by, and hence can be said to be caused by, the operations of the total dynamic system according to the laws which we today find to be operating. This is quite different from a common and mistaken interpretation of thermodynamic laws of only a few decades ago. Today it has become clear that the evolution of events in the cosmos is a prior totality out of which flow the evolution of the events we call biological and human. Man is not alien in, but a creature evolved in the service of, the dynamic flows of the surrounding world.

We can interpret properly man's position in the scheme of things as follows. On earth, man is the special creature at the apex of the successively evolved levels or stages of increasing order and control in the historical or evolutionary process. In man has been created an increasingly conscious awareness of a model of the creating process and man's duties and opportunities in it. He has been made an agent of the process at its farthest-advanced level of control and will continue in this role so long as he conforms to the overall requirements of the total dynamic system of energy flow or power.

Ecological systems, as they go through their succession of dynamic patterns, increase their degree of orderliness, develop better cycles, improve their control mechanisms, and form patterns that increase their productivity and consumer energy flows. When ecosystems and the systems of humanity are similarly diagrammed, the patterns of systems energy are found to be similar, showing the universality of energy laws that apply to the large and the small. The tremendous complexity and variability of human individuals begin to make sense. Individual choices are a means for exploring alternatives so that humanity as a whole finds the patterns that maximize the system's energy flow. Most people are accustomed to thinking of human behavior as the cause of behavior of the larger systems. They have difficulty realizing that patterns of the system can draw from the individuals the behavior that helps the system track maximal power through competition of variant patterns for survival. Diagrams may help. Figure 2 is an example of the web of energy flows and feedbacks

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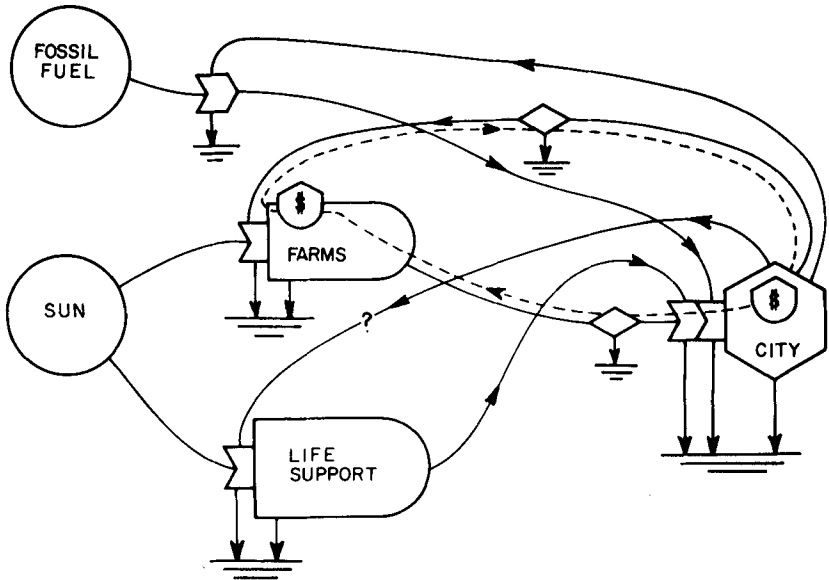


FIG. 2.—Energy flows in the ecosystem of the biosphere

characteristic of our world. Energy inflowing (from circles) after doing work outflows through used-energy arrows, pausing in the storage tanks and interacting with other flows through the pointed blocks. Characteristic system designs are usually found and readily explained by the maximum power tendency.

Feedback Interaction. Illustrated in figure 3 is the feedback of stored energy acting to help pump in more energy. The feedback is high-quality energy that is amplified by interacting with the energy source. The storage is a necessary feature of controlling the feedback pumping action. Used energy, no longer usable for work, flows from each process (interaction symbol) and from depreciation of the storage. The characteristic pattern of figures 2 and 3 shows energy circulating in loops. Where humans are involved with money exchanges, the money runs in a countercircle being given in exchange for the energy-bearing flows. Energy comes in, circles, and goes out used; money turns in closed circles.

Material Cycle, Order and Disorder. Another characteristic property of systems caused by energy flows is the cycle of materials as shown in figure 4. Materials move along with the energy from a disorderly state, interacting with an energy source to develop orderly products in storage. As required by the law of energy degradation (the second

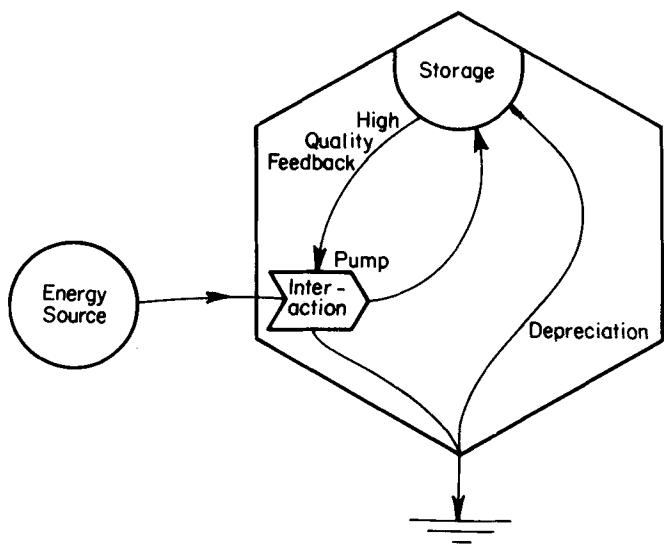


FIG. 3.—Characteristic design of each component with a feedback of high-quality energy to help maximize power.

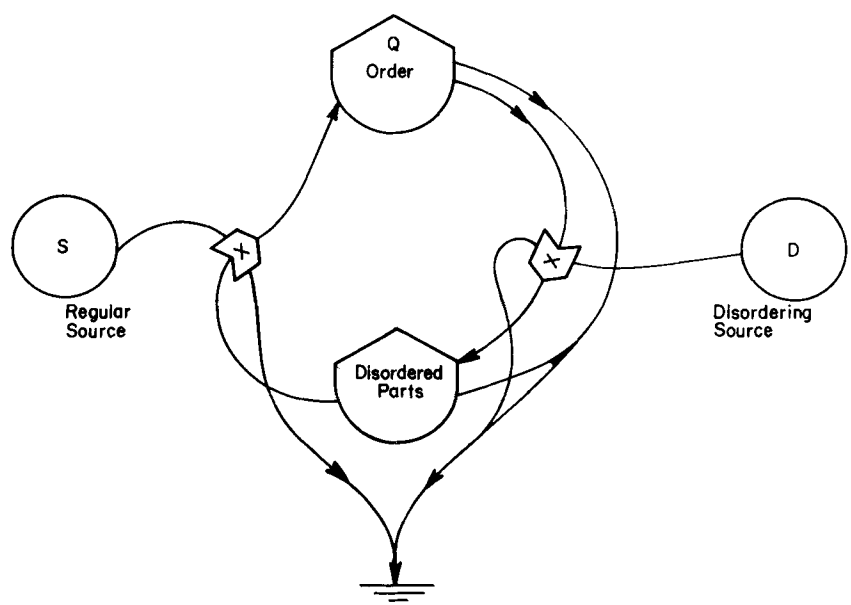


FIG. 4.—Characteristic pattern of order and disorder in symbiotic relationship

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law of thermodynamics), these storages spontaneously disperse their concentrations back into a disorderly state. Examples are the cycles of mineral nutrients in ecosystems and the cycle of materials in industrial production.

Examination of the diagram in figure 4 and computer simulation of its mathematical translation show that order and disorder storages are coupled. Maximum power requires some of each. When there are not enough disorderly materials, production is inhibited; when there is not enough order, recycle is inhibited. Closed loops of order and disorder like that shown are automatically symbiotic, each part of the circle controlling the rate of flow through the other.

Many aspects of the human system of generating choices use disorder, which makes possible faster adaptation and evolution than in the more rigid biological mechanisms. Alfred E. Emerson and Ralph Wendell Burhoe show the features of human systems, such as freedom, that lead to effective adaptation.³

Order is often associated with angelic ideals and assigned high value. Much of humanity is concerned with using energy sources to generate order to keep up with disorderly tendencies of storages. Disorder is sometimes associated with the devil or other representation of the random, the hot, and the unorganized. If both order and disorder are required to maximize the creativity, flexibility, circulation, and flow of energy, then both are of value and either may be of short supply in a real situation.

H. H. Barnette reviews the role of man and his theology in the order of the biosphere.⁴ In an appendix he raises the question as to the role of evil, a word used often to describe damage to man, sometimes by other men, and sometimes by natural catastrophe. Using order-disorder models to gain a larger perspective, one can view evil as a flow into disorder that has its necessary role as recycle in generating effective ordering processes. What sometimes seems evil to man is often good on the larger scale of the biosphere that humanity survives to serve and must serve to survive.

Energy Quality Chain. Although the energy web like that in figure 2 is characteristic of systems of energy flow, these may be aggregated into energy chains to help visualize principles about energy transformation. Figure 5a depicts a typical energy chain such as is found in food chains in ecology, occupational chains in industry, and chains of physical processes in the ocean and atmosphere. At each stage energy is transformed to a new type that is capable of feeding back as a multiplier. In achieving higher-quality energy and ability to control, energy is used and leaves the chain through the used-energy arrows to the heat sinks. There may be no more than 10 percent of the

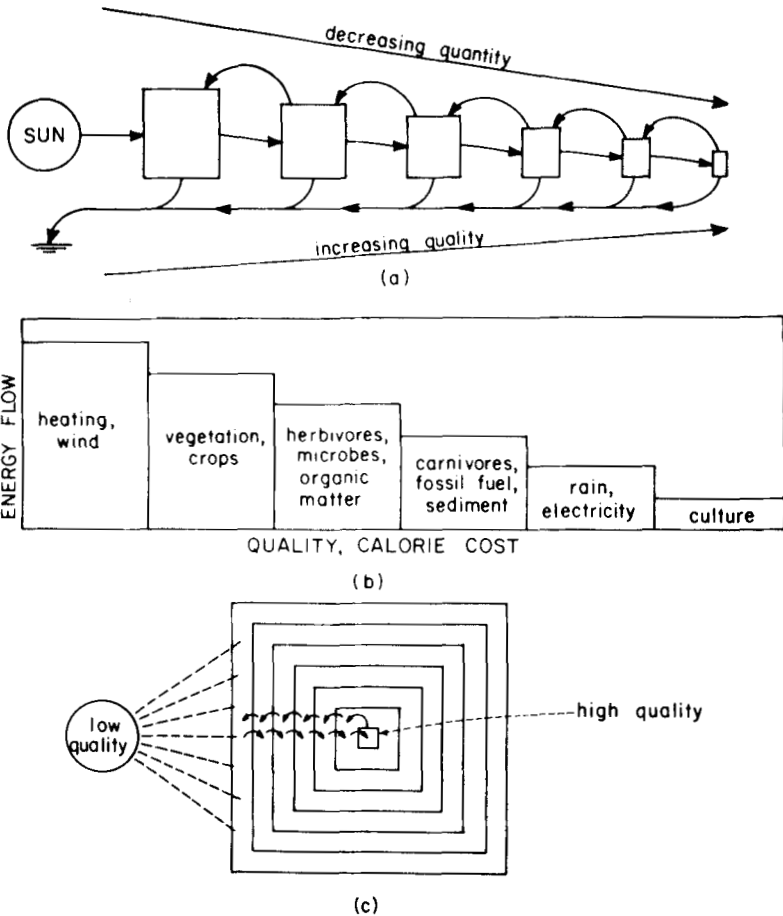


FIG. 5.—Concept of equal-quality chains. *a*, Energy transformation chain. *b*, Graph of declining energy flow. *c*, Diagram converging cumulative energy used to develop each calorie of high-quality energy.

entering energy remaining beyond each transformation, but the quality goes up with each step. In a long chain there may be ten thousand calories of low-quality energy such as sunlight converted into one calorie of high-quality energy such as electricity or into a top carnivore. On the left flows are large as measured in calories of heat equivalence, whereas the flows on the right are few in calories but large in impact acting as an amplifier when they feed back as shown in figure 6*b*.

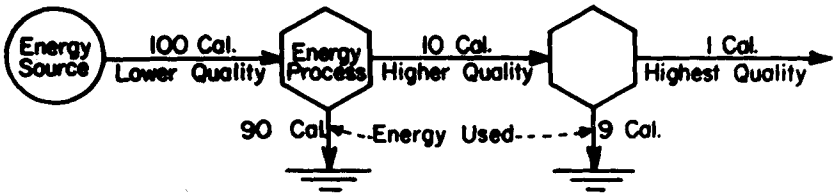
Information, Spatial Concentration. Notice also that the upgrading of energy quality is accompanied by concentration of energy into a

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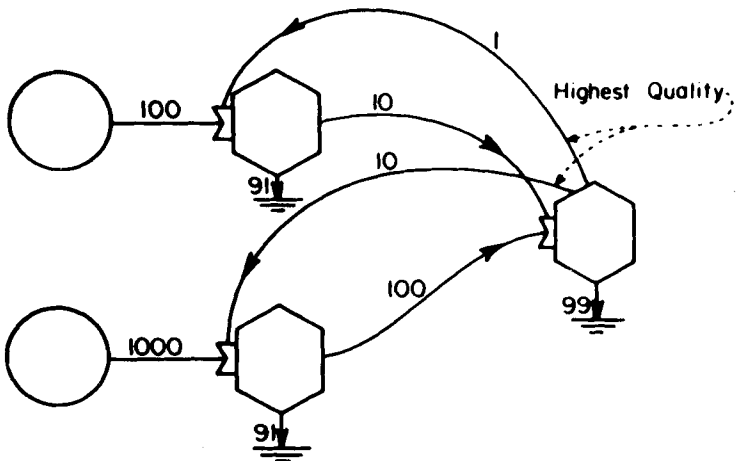
smaller geometric space. Going up the food chain to higher quality converges, whereas the feedbacks that control energy are high-quality feedbacks, diverging outward and difficult to measure. The highest-quality flows are information.

ENERGY BASIS FOR VALUE

The energy chain shows the stepwise increase in energy quality paid for by use of energy at each step. The amount of energy used to develop and increase quality is a measure of that value, provided the system has been exposed to real conditions of selection for maximum power under competition. Figure 6 shows an example of energy



(a)



(b)

FIG. 6.—Diagram showing the definition of energy quality factors and way of calculating energy equivalents for one type of energy in units of another. *a*, Concept. *b*, In a web.

transformation cost. The ratio of the energy input and output is called the energy quality factor. The concept is easy to visualize when isolated as in figure 6*a*. It is more difficult when, as in figure 6*b*, the transformation has several inputs and outputs.

Energy basis for value is defined as the calories of heat equivalents used under competing circumstances to develop a calorie of heat equivalents of the higher-quality form. The energy is of higher quality because of its amplifier ability. Theory has it that high-quality energy is not developed under competing circumstances unless the feedback generates as much effect on its upstream source as was drained downstream. If the aspects of human value, region, and other high-quality intangibles can be placed on a chain with the energy flows shown, the energy cost values of intangibles may be estimated by the cumulative energies used.

To help compare energies of different quality located in different aspects of the energy chain on earth, we develop tables of energy equivalents for converting all energies to the same quality, such as solar equivalents or coal equivalents. Value and ability to do work contribute to maximum power and thus contribute to the survival of one's system. Value may be best measured by the energy, providing all comparisons are in equivalent units.

FLEXIBILITY OF HIGH QUALITY ENERGY

A characteristic of energy chains is the increasing flexibility of use that goes with high quality. We observe high-quality energies used with flexibility, and they probably have to be if they are to feed back, diverging to many parts of the system from which energies were converged. Electricity is much more versatile an energy than sunlight or wood; top carnivores in food chains are more versatile in their feeding habits and services to the system than the algae or the primary consumers. We think of the top carnivores and the electrical devices as smart. Human beings with their brains are examples, too.

ROLE OF MAN, SOCIAL SYSTEMS, AND GOD

When humanity is considered in the webs or chains of energy flow, we find human beings far to the right as a form of concentrated, high-quality (but low-calorie) energy. Although most humans in the recent century of rich and rising energy have lost awareness of environmental responsibility, the role of humans is one of service. Humans provide complex control and management actions back to maximize the main power and survival of the whole system.

Figure 7 shows the role of humanity as high-quality energy components serving the landscape or ecosystem in exchange for life support.

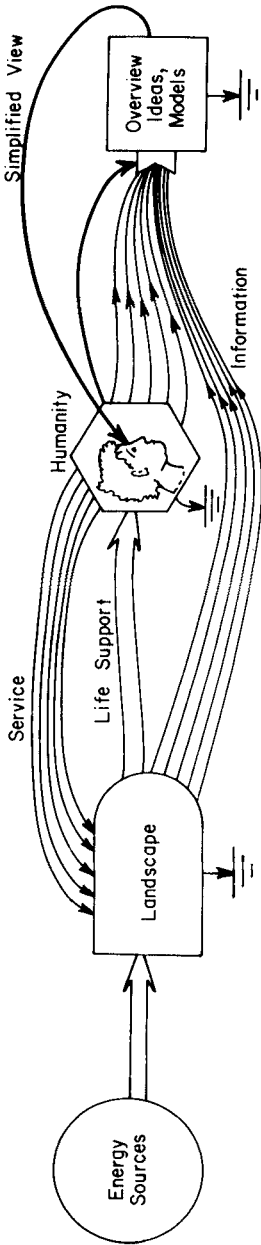


FIG. 7.—Diagram showing the role of man within the system of the biosphere sensing, interpreting, and acting on the basis of simplified ideas and models generated to help the system gain an overview image of itself.

The combined decentralized system of interacting parts of our universe is sometimes regarded as God. This interpretation sees humanity as a part of God. Order and disorder are necessary components to be managed by man, but not according to whim. In religious terms man is sometimes said to be in the image of God. This relationship is better stated another way: Man as the high-quality culmination of diffuse parts of the system is the means by which the system visualizes an image of itself.

It is sometimes said that no system can understand itself. A doorbell buzzes but does not know how it did it. A human knows how a doorbell works, but he does complicated things that he cannot understand. It takes more components to understand than to be. The logical extension of this theorem is that the system (God) in its shared network of information processing does not completely understand itself. The whole system has a giant intelligence which is smarter than its components and may even have some consciousness or "group dynamics" that understands humans, but it cannot understand itself fully.

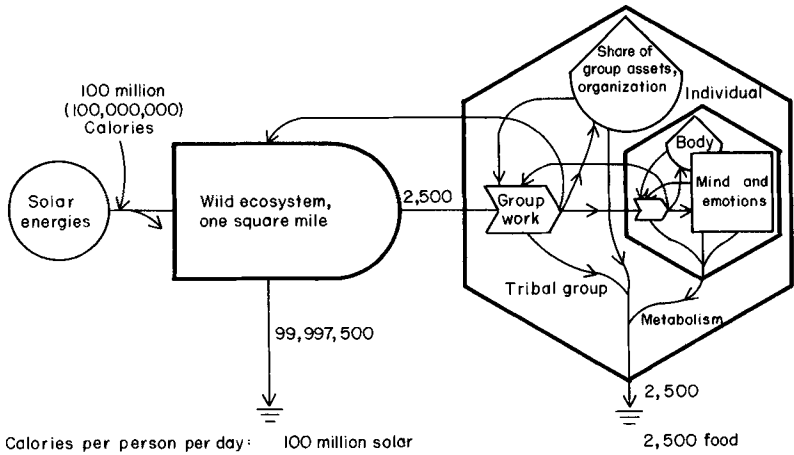
The way a system can understand itself is to develop simplified ideas, sometimes called models of itself, which have enough of the main features to have some reality but are simple enough to be understood.

In figure 7, shared but simple ideas (models) are shown being generated. Such activity is of an even higher quality of energy than the general level of humanity. Overview models are more concentrated and capable of greater amplification in feeding back as control and service. Examining the system as a whole (fig. 7), one sees humanity as the intelligent component of God generating models by which the system can see enough of itself to improve its operation and maximization of power. One role for humanity on earth is to help the system see itself. Models are portrayed often with highly concentrated informational devices, including educated brains, the television networks, and computer outputs.

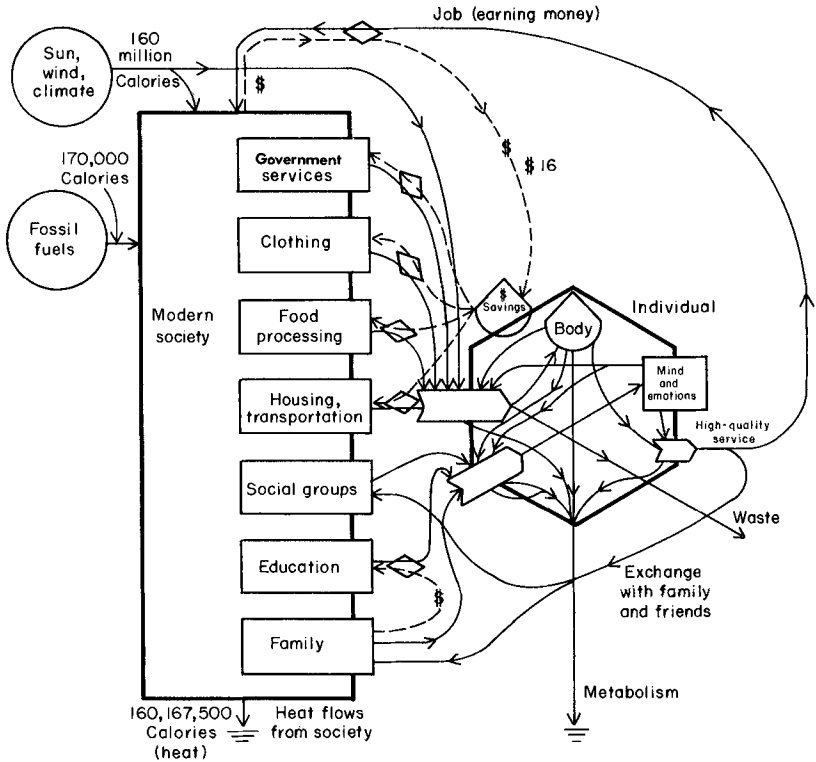
VALUE OF MAN

Placing man in an energy chain for which approximate energy flows are known (at least for the average) allows us quantitatively to estimate the value of man from the calories of energy spent in developing and maintaining him. When energy flows are high as in an industrial world, the energy spent per person is higher than in simpler agrarian societies, based mainly on sunlight. As described in the previous paragraph on energy value, units are converted to energy equivalents of the same quality.

Figure 8 diagrams the human role in a hunting-and-gathering soci-



(a)



(b)

FIG. 8.—Energy basis for an individual human. *a*, Energy basis of an individual in hunting and gathering. *b*, Energy basis of an individual in a modern society. (From Howard T. Odum and E. C. Odum, *Energy Basis for Man and Nature*, 1971. By permission of McGraw-Hill Book Co.)

ety compared with present roles for humans in an industrialized society. Because humans were so dilute and were the culmination of so many acres of solar energy, the energy value of humanity was quite high in the primitive state. If energy (expressed in units of the same quality) is a measure of quality of life, we have nothing to fear in going to a lower energy state, provided there is some drop of population density to go with it.

Energy quality evaluations put human attributes in perspective. The following are some examples of quality evaluations using the scale of equivalent costs in units of solar energy. In calories of solar equivalents per calorie are plants, 1,000; coal, 2,000; electricity, 7,200; human food, 20,000; simple human service, 200,000; educated human service, 2,000,000. Even further out the quality value chain are spiritual values which have tiny calorie contents but very high calorie costs in their generation.

ROLE OF RELIGION AND SPIRITUAL VALUES

Within the body and activities of man there are many qualities of life. Energies of food and those of other inputs to the human being interact to generate processes in organs, heart, nerves, and the brain (of highest quality). Within the functions of the brain are many levels of function and learning, one of which is the central program of basic responsibility to the surrounding system. The individual's basic morality is inherited and nurtured information, often the target of organized religion. Associated with the superego in some people's concepts, the basic morality program is one of the first parts of the child to be organized while the human is still simple.

Figure 9 diagrams a chain of energy flows in which the human is separated into body functions, mental processing of information, and finally, developed from the latter, the central cluster of important essence that controls the rest. This program with central controlling role is postulated as of high-energy quality requiring the convergence of much energy and processing of much information. The high-quality essence may be the soul in the terminology of others. Burhoe reviews the scientific basis for the soul as the core nature of a man, including a genetic inherited component, a culturally inherited component, and an environmentally inherited component.⁵ Whatever we call it, a soul is influenced by the church and feeds back to the rest of the system directly and indirectly to keep the information and human as a whole reinforcing the basic productivity of the system, maximizing power.

Because the soul as defined within the energy quality chain is of very high quality, it is a very flexible energy. It readily interacts with other

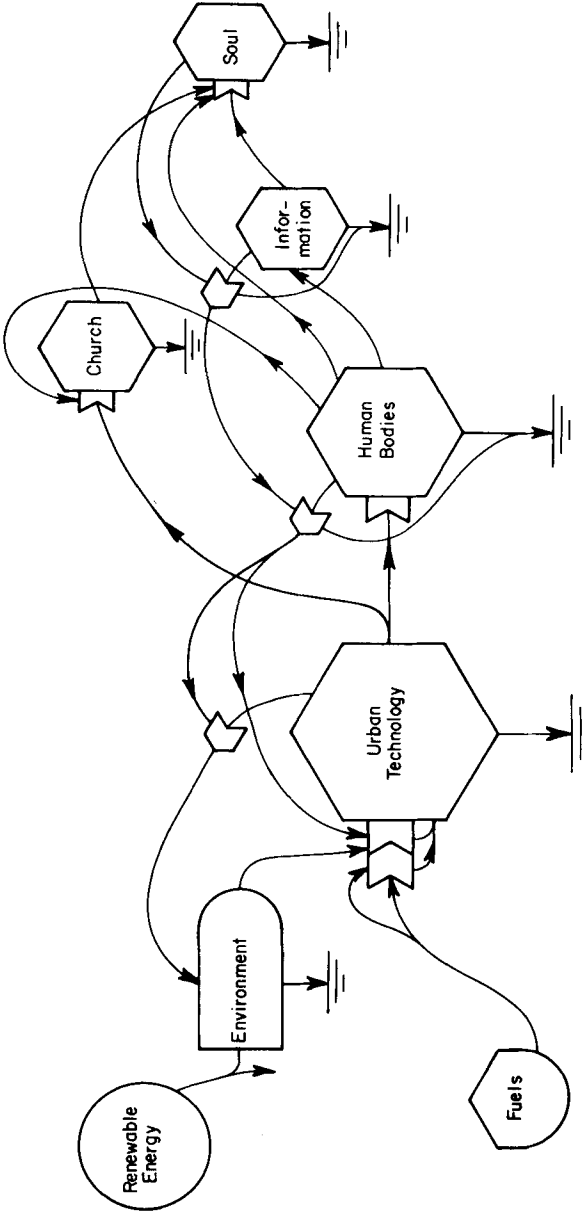


FIG. 9.—Diagram of the position of human body, human information, and the central essence of the soul in the chain of energy quality. Renewable energy flows ultimately are from the sun.

parts of the system and has enormous power if it amplifies an energy source.

As discussed in a previous book, the parts of a person's most important essence are unique and require special energy to develop.⁶ They are the parts that are made partly immortal by being absorbed by the system, usually a little at a time—in teachings, in one's children, and in one's writings. Whether personified as a supernatural entity or not, the recognition of a high-value personality core is what is important.

The soul is analogous to the fruits and seeds of trees. Both are high-quality energy used to help reproduce the system, both are useless alone, and both are powerful if they are interacting with a general energy source. Little wonder that there is a struggle for souls in the institutions competing for influence.

FAITH AND INDIVIDUALISM

Faith in one's system is a part of a human's relationship to his biosphere, which can be an important part of religious teachings. Faith is the acceptance of the primacy and intelligence of the system (some call it God) and the value of working on its behalf (not faith in leaders necessarily). However, we do not need restrictions on the individual's freedom to test out new ideas. Each person should plug himself into the system in the way that seems to be best considering his individual abilities and background. Freedom is important for improving efficiency of service to the system.

SIMULATION OF IDEAS

When humanity serves by generating ideas and models, computer simulation may help by showing the kind of graphs with time that are characteristic of the models. In simulation the features of a model interact, generating graphs of growth and decline like those in figure 10. In simple examples like these one can visualize the shape of events with time without computer by visualizing the models as if there were tanks of water filling and draining as flows of water are passed or pumped along the pathways. Think of the interaction symbol as a mutual pump, each flow helping the other.

In more complex models the mind cannot so easily visualize what the results will be because there are too many flows interacting at the same time. Computer simulation shows what the actual consequences are that follow from a particular energy diagram.

Figure 11 is an example of a model with its computer-simulated graph. The levels of order and disorder are graphed with time. Also graphed is the rate of production of order which is in the inflow into the order tank.

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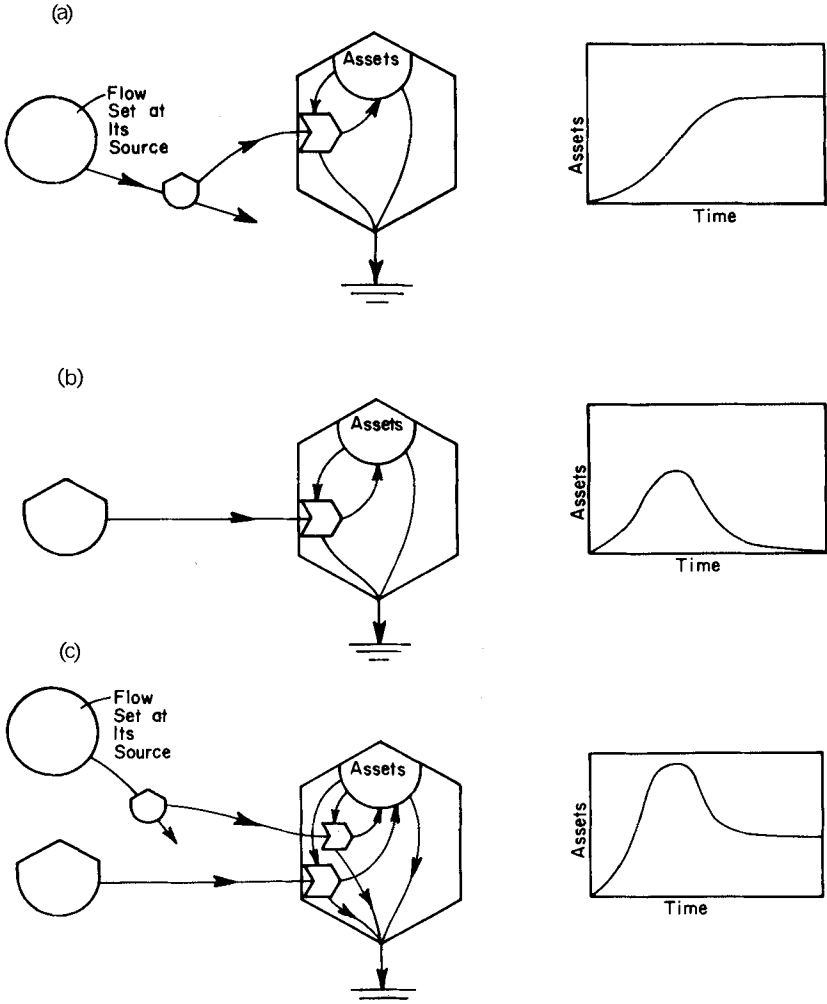
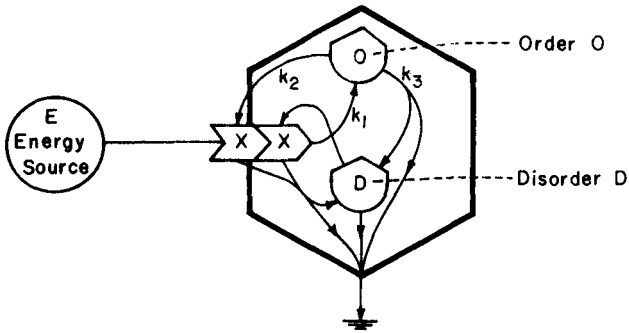


FIG. 10.—Types of growth that follow from computer simulation of types of energy sources. These can be visualized as if water were flowing in pipes in and out of tank. *a*, Steady renewable energy flow limited at its source. *b*, Energy source a storage of non-renewable high-quality energy which supports temporary growth and decline. *c*, Both of the energy types found in *a* and *b*.

One of the steps in computer simulation is to write mathematical equations which are another language for describing relationships diagrammed. The first equation says that the total material resources in order form (*O*) and disordered form (*D*) are constant (1 meaning 100 percent). The second equation in figure 11 says that the rate of



$$O + D = 1$$

$$\dot{O} = (k_1 - k_2)EOD - k_3O$$

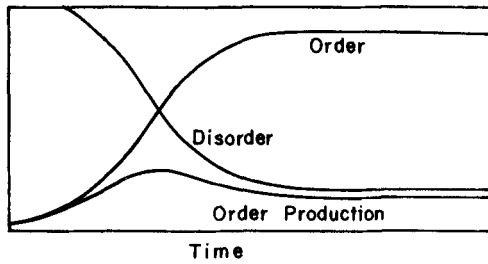


FIG. 11.—Simulation of models which relate the information of the soul to the system it serves; a unit in which angelic order production is proportional to both order and disorder and to an unlimited energy supply.

change of order ($O \dot{}$) is the sum of the production inflow (k_1 times E times O times D) minus outflow pathways.

Figure 11 is a model of order production slightly more complicated than the ones in figures 3 and 4. In it, both the supply of order and the supply of disorder help pump inflowing energy into order to keep up with depreciation. This model makes some disorder essential while giving order a controlling role.

GROWTH AND STEADY STATE

Simulation provides graphs of the state of the system with time. There are two main states, growth and steady state. One may tell fairly well from the shape of energy diagrams what the kind of growth will be.⁷ The simulations in figure 10 were started with a low-energy condition, and more energy was added after which the system developed more structure and process. When supplies of

ZYGON

lower-quality energy were increased, more high quality was generated.

In figure 10 are some main types of growth curves that are expected for the kinds of energy sources shown. In *10a* the source is a steady flow limited to that flow at the source. The assets of the system level off after a growth period. In *10b* the source is a storage of a small quantity of high-quality energy that will drive much growth while it lasts. Then the assets that depend on this source eventually will fade away. In *10c* a rapid rise is followed by some decline and leveling off that comes with both types of energy source. This minimodel is the most pertinent to the world energy resources and our system. Rapid rise is accelerated by oil and other minerals; the final steady state is based on solar energy, water, wind, etc., again.

For each of these states, religious institutions and the energy for spiritual values are processed differently. In growth, faith is in progress and a cluster of characteristics of culture and individual attitudes that go with growth. One must grow if one can in order to maximize the system's power.

In steady state, faith is not in progress but in service with little change. Individuals with appropriately adapted spiritual values generate the most power. In steady state this means not trying to grow and not trying to dominate; instead emphasis is on the unity and diversity required for best use of energy in service to the biosphere.

Sometimes efforts are made to distinguish between religions as to their emphasis on growth versus steady state or on narrow view of humanity first versus humanity as an environmental steward. Locally such differences can be shown, but over the long range the world's long-surviving religions have been those with the flexibility to switch back and forth as needed, programming and reprogramming the group behavior of each generation toward the roles that maximize power then. Such changes are happening again now.

SYMBIOSIS OF SPIRITUAL AND PHYSICAL ASSETS

The model in figure 12 separates the main physical and energy storing structure from the storage of spiritual values—information and soul. Notice that each is shown pumping the other. Only the spiritual values are shown as saved and recycled to start new generations where they can interact to pump new energy flows into new beings and orderly systems. Computer simulation shows that either this model can grow rapidly where the energy sources are strongly forcing and unlimited or the system will grow to a plateau and level off if the energy flow is a steady one of renewable type. The symbiosis of the

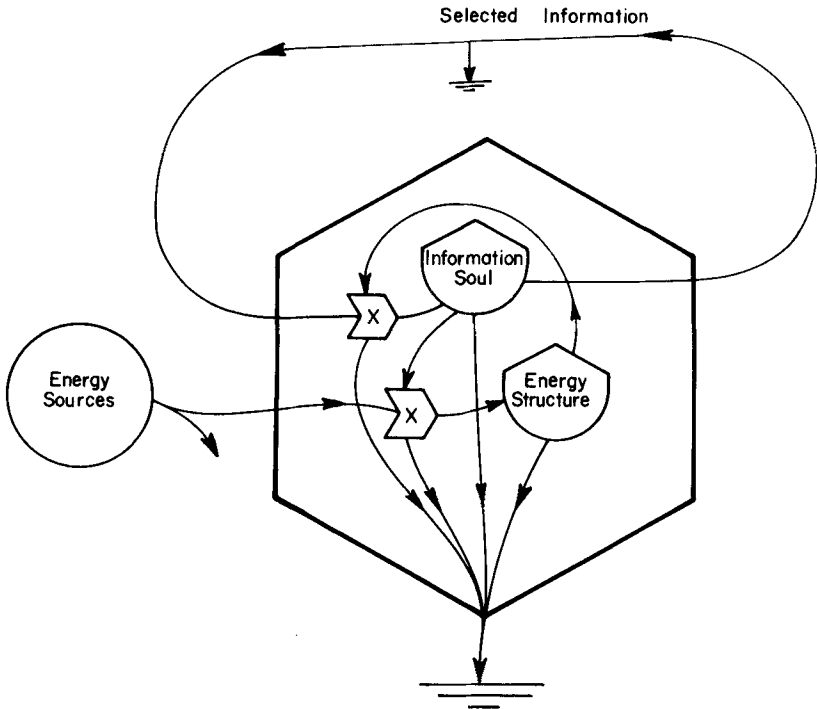


FIG. 12.—A model of information and energy storage in which information is recycled in the manner of choosing souls for immortality.

physical and spiritual is flexible in generating whatever energy usage maximizes power under the circumstances. Given in figure 13 are traditional Christian images that go with this model.

EXAMPLE OF JAPAN

Japan is a good example for comparing culture in steady state running on renewable resources and more recently in rapid growth on temporary stored energies.

In figure 14 is an energy-flow diagram of Japan's rural culture. Rainwaters and wood from hillsides interact with rice paddies and fishing from the sea. Figure 15, in contrast, diagrams modern industrial Japan with major fuels brought in from outside in exchange for high quality of work in generating exports. One of the ways of maximizing power in addition to accelerating growth or being more efficient and diverse is to exchange for scarce items with other areas, in this way bringing in energy flows with high quality and amplifier action.

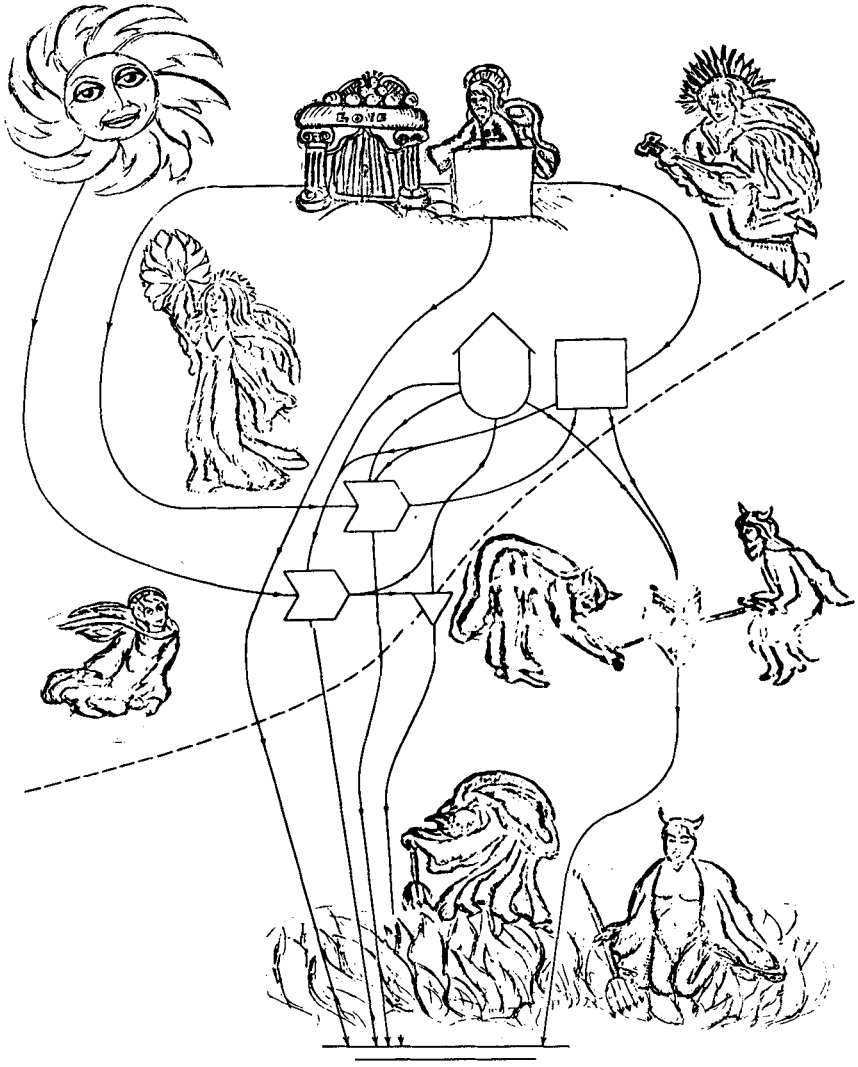


FIG. 13.—Artistic rendition of model sketched in fig. 12. (Art by Ann Odum.)

The rural ways were of lower energy, simple, but evolved over a long period with harmony. A key to the pattern was the use of mountain waters to operate the rice paddies. Soy beans fixed nitrogen from air as fertilizer to the soil and also became important to the diet. A general hypothesis is that culture evolves to fit the energy pattern. Part of this basic life was Shinto religion that had symbols, faith, and

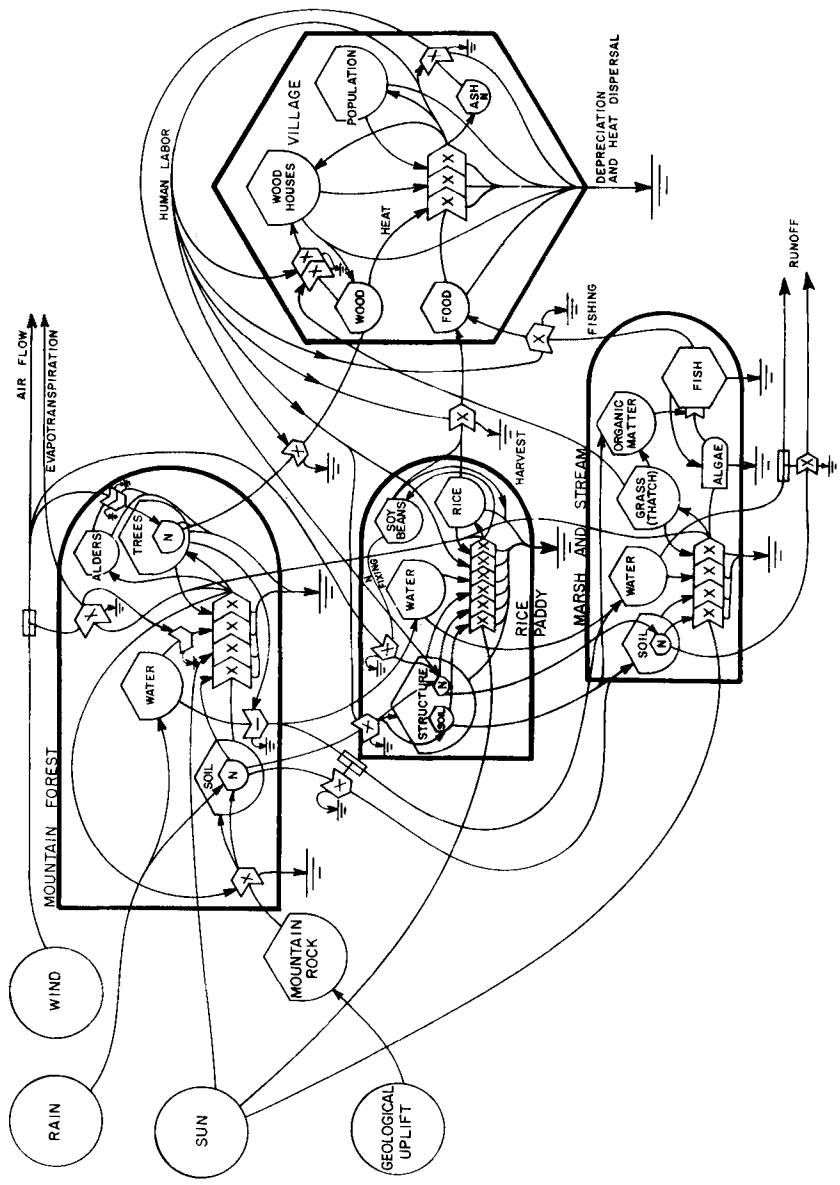


FIG. 14.—Energy-flow diagram of Japan: original rice culture on renewable resources

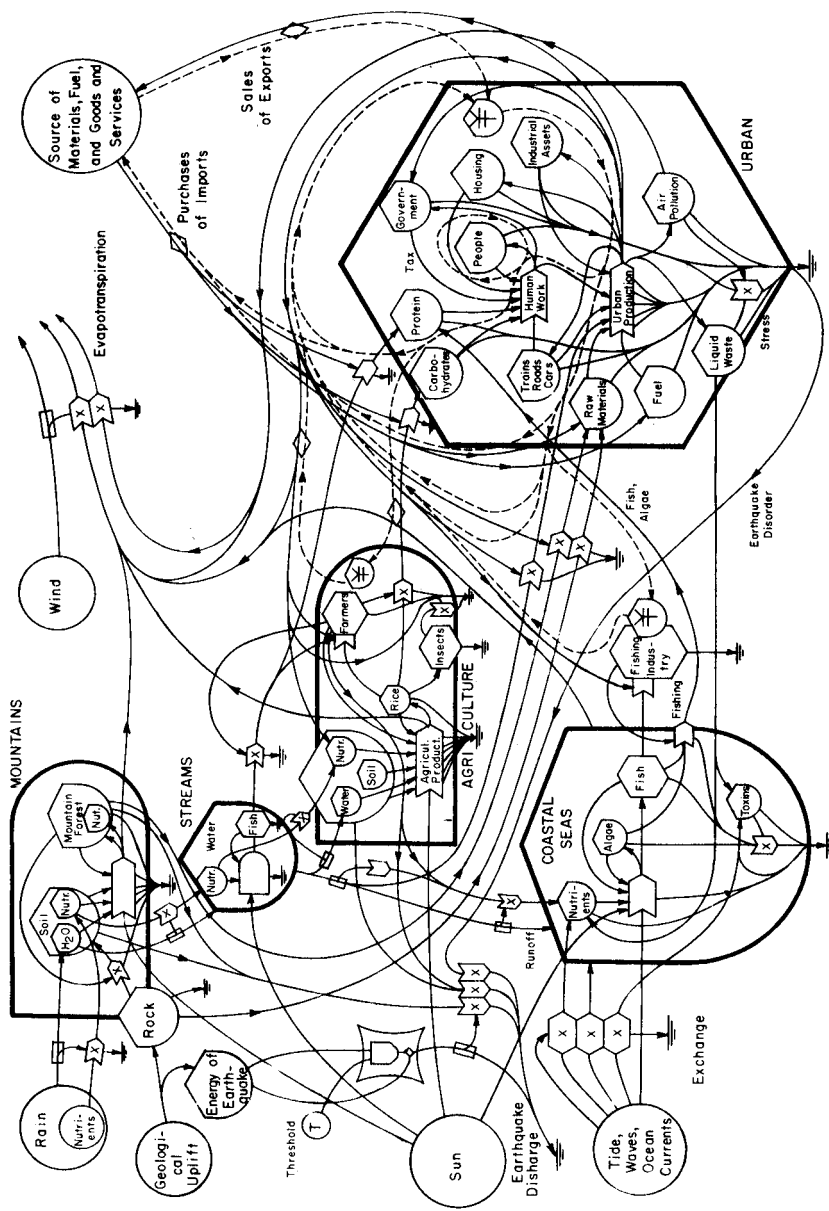


FIG. 15.—Energy-flow diagram of Japan: industrial economy in part based on imported fossil fuels

fears tied to the forest. The purity of waters kept the human in balance with the forest.

With the addition of much new energy the old religion was inadequate. Waters were still used to clean everything and flush it seaward, but now the energy flow was too concentrated and the environmental recycling inadequate. Poisonous conditions developed; poorly planned use of water contaminated the shallow seas so important to the protein food of the Japanese. Instead of streams allowed to meander among a cleansing mosaic of forest plots and rice fields, channelization wastefully dumped water and waste seaward.

With high-energy flows there is more disorder. When there is more disorder there are more choices. All patterns become fluid. Times have been ripe for spending energy to develop new, high-quality spiritual values. There have been a great variety of trial patterns, mixing of ideas, and uprooting of old patterns. Now with the reduction of energy again (Japan now has to buy fuels at high cost) the creative period must decline and there become fewer patterns of religious control and, for individuals, fewer types of souls. In due time one may expect an emerging new pattern that fits the new regimes of lesser energy. Symbiotic roles that control the landscape will maximize values from the energy of renewable resources.

OPPORTUNITIES FOR OUR FUTURE

What are our own roles in changing patterns of energy? What spiritual values and religious patterns will maximize energy flow in the approaching times of energy decline and leveling to steady state? Total energy will be less, and the value of humanity will have to decline some along with that of the whole system. Anticipated are more efficiency, diversity, antiprogress feelings, flexibility, lower diversities, and smaller-scale patterns.

With less energy to be converged, energy to organize larger regional and national and world systems will decrease. Religious institutions again may be left to each locality to make special adaptations. The mission is to adapt religious programs and the souls of individuals toward the most effective service for maximum power flow of the system. Opportunity to achieve a pattern that will be long lasting will be greater than during growth. The individual's work can be much more everlasting. Many of the pathologies of superheated energy flow, such as mental disturbance, crime, and disorientation, should diminish. The future is optimistic but not in the sense of progress and growth. These may become bad words when energies are steady.

There may be some practices that we now would regard as quaint

ZYGON

or ridiculous. Just as the artifacts of the Roman civilization were incorporated in religious faiths, dogma, and practice in the middle ages, so our towers, skyscrapers, nuclear power plants, and great highways may develop quasi-religious significance. Each system uses the storages left over from the past to augment its system. These great storages will be used for many purposes, including use as symbols of power of past forces no longer understood.

THE NEW HOMESTEADING

Perhaps we all need a new project to help with the transition, one that leads from the high-energy urban growth pattern to the rural lower-energy steady state. As lands held for urban expansion become available with bankruptcy and as cities become more vacant as the energies there dwindle, our people need to move back to small towns. Then some will move back on the land, using more solar energy and labor in agriculture. There will be more subsistence, more diversity, and more harmony in symbiosis with the land. How can we promote this?

Perhaps church lands and lands given or leased can be provided with appropriate enabling laws for new homesteading. Those who live in existing housing of suburbia can begin to work the lands nearby. New social and religious institutions will have to develop for the new homesteading.

With steady energy flow patterns fewer children are needed and the pioneer family structure will not suffice. The pioneers did intense harvesting of storages of forest, minerals, and soil. The new era will be in slower tempo in balance with the rains, uplift of the land, and the work of the sun.

As the scale of things turns smaller, the individual will become more important. His religion and ethics will be that of small groups. Individual morality and the religious institutions once again will replace the lawyers and government as custodians of good social behavior.

How about having a nationwide contest on suggested plans for social, economic, and religious structure of the new homesteads? Currently in the United States the movement to the land is delayed somewhat by the exchanges of grain for oil which temporarily allow industrialized agriculture to continue as a mainstay of the American economy. However, as energies remaining are found deeper and deeper, and more needed by the countries now selling them, the opportunities for maintaining our energy flows will decline gradually. Let us be ready with sermons to the citizens as to the models by which God through his human eyes can see what is to be done.

NOTES

1. Howard T. Odum, *Environment, Power, and Society* (New York: John Wiley & Sons, 1971); Howard T. Odum and E. C. Odum, *Energy Basis for Man and Nature* (New York: McGraw-Hill Book Co., 1976).
2. A. J. Lotka, "Contribution to the Energetics of Evolution," *Proceedings of the National Academy of Sciences* 8 (1922): 147-55.
3. Alfred E. Emerson and Ralph Wendell Burhoe, "Evolutionary Aspects of Freedom, Death, and Dignity," *Zygon* 9 (1974): 156-81.
4. H. H. Barnette, *The Church and the Ecological Crisis* (Grand Rapids, Mich.: William B. Eerdmans Publishing Co., 1972).
5. Ralph Wendell Burhoe, "The Concepts of God and Soul in a Scientific View of Human Purpose," *Zygon* 8 (1973): 412-42.
6. Odum.
7. Odum and Odum.