A Short Introduction to Environmentology

By

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Contents

Preface

It is said that the 21st century is “the century of environment.” Nowadays the media report about the environment every day. So we know a variety of environmental problems exist; for example, global warming, the depletion of the ozone layer, tropical deforestation, air pollution, water pollution, increasing waste, and damage to the health due to chemical substances.

On the other hand, the process for solving environmental problems is ambiguous. We are always pressed for treating one problem after another and never end up finding the proper solution. We live from day to day with the anxiety that irreversible misfortune may happen in the future.

Why don’t we have brighter prospects for solving environmental problems? One of the reasons is that we only understand them in fragments and lack a comprehensive understanding. What is the root cause of environmental problems? What is the driving force that has produced such problems? What is the vision that we should share in the 21st century? What is a key to achieving this vision? For the series of questions mentioned above, we have not provided a logical answer.

Conversely, if we answer these questions appropriately, we can clarify a process to solve them and take measures accordingly. Actually, it is “environmentology” that helps achieve this purpose.

This description introduces the essence of environmentology concisely. This description consists of six chapters. The first chapter explains the essence of environmental problems and shows the definition and framework of environmentology. Chapter 2 and Chapter 3 provide background information on the environment and environmental problems, tracing the history of the earth, life, humans and human activities. In Chapter 4, after reviewing the history of environmental problems, I show the vision that we should pursue. Chapter 5 and Chapter 6, respectively, clarify the process for achieving that vision from the two aspects: technology and social reform.

Environmentology furnishes a key to solving environmental problems. Using this key, let’s open the door to a truly prosperous future.

The Japanese original of this translation first appeared serially on an environmental magazine named *Kankyo-Kaigi*, which was issued by *Senden-Kaigi*, a publishing company in Tokyo, from 2000 to 2001. Later in 2001, it was brought out as the booklet titled “*Korekara Hajimeru Kankyogaku*” by *Kamogawa-Syuppan*, a publishing company in Kyoto.

Chapter 1

What is “Environmentology”?

Seeing a Clearer Overall Picture of Environmental Problems

The other day, a friend of mine who works at a local government told me his experiences. He was involved in setting up the basic municipal plan which describes the vision of the government. He was in charge of the environmental policy of this basic plan and put all of his energy into surveying and drafting the report. However, as the work progressed, he gradually felt uncertain. His mixed feelings were a result of the lack of a clear overall picture of environmental problems.

He said, “Now there are a variety of environmental problems, for example, an increase in waste, dioxin contamination, the destruction of nature, water pollution, pollution from cars, and global warming. But I cannot understand the root cause of these problems. So I feel it hard to find thorough solutions to environmental problems, and we tend to take measures to treat the symptoms.”

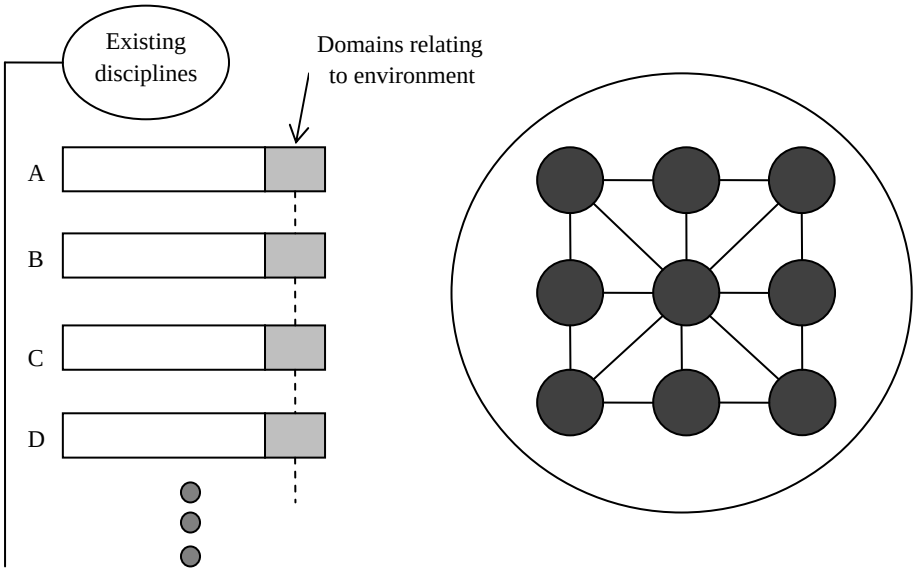
Probably there are many people who feel that environmental problems are hard to figure out. Such feeling results from the present situation in which information about environmental problems has not been organized although vast information has been accumulated. This chaotic situation is closely related to the present state of science that deals with environmental problems.

Present Situation of Science Dealing with Environmental Problems

Recently, as environmental problems have become more serious, the scientific world has greatly changed. As proof, domains of study, in which the word “environmental” is attached as a prefix, keep coming into existence to form the name of a variety of disciplines. Examples in natural science are environmental chemistry, environmental biology and environmental engineering. Instances in social science or humanities are environmental economics, environmental law, environmental sociology and environmental ethics. Moreover, many other disciplines such as history, geography, pedagogy and agriculture have produced similar domains although they do not have proper names for them yet.

However, this academic situation seems to be temporary. An especially problematic point is

that each domain tries to approach environmental problems individually and hardly ever collaborates with other domains (Fig. 1a). Incidentally, this point relates to the unclear overall picture of environmental problems and the delay in solving them.



(a) Present situation (b) Environmentology

Fig. 1: Current academic approach to environmental problems (a) and Environmentology (b)

The Essence of Environmental Crises

Fig. 2 schematically shows human activities performed on this earth. In the 20th century, human activities increased explosively. The world population increased from 1.6 billion people in 1900 to over 6 billion people in 1999. Energy usage which is often used as an indicator of abundance increased at an even greater pace than the world population. An increase in human activities has also resulted in an increase in a variety of wastes: for example, metals and synthetic chemicals, gases produced by burning fossil fuels, and nuclear waste. Among these wastes, what is discharged with the utmost volume is carbon dioxide (CO_2) produced by burning fossil fuels. A part of emitted CO_2 is absorbed by oceans and plants; however, the other part accumulates in the atmosphere. Therefore, the atmospheric CO_2 concentration level has been rising since the beginning of the industrial era and recently the upward rate has been speeding up. Atmospheric CO_2 has the greenhouse effect and increased amounts of

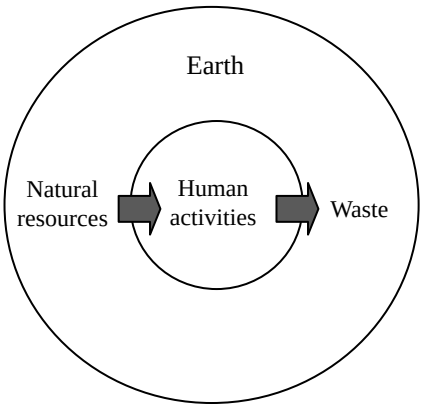


Fig. 2: Schematic depiction of human activities on this finite earth

CO_2 warms up the earth. As media often inform, global warming causes the rise in sea levels and an increase in abnormal weather.

Table 1: Fossil fuels reserves-to-production ratio

	Oil	**Natural gas**	**Coal**
Proved recoverable reserves (R)	107.71 billion barrels	147 trillion m^3	982.1 billion tons
Production (P, 1996)	2.46 billion barrels	2.3 trillion m^3	4.65 billion tons
Reserves-to-production ratio (R/P)	44 years	64 years	211 years

Burning fossil fuels implies that the same volume of coal, oil and natural gas disappears from underground. Since the earth is finite, these underground resources are also finite. Therefore, if we continue digging up these resources on a massive scale as we do now, they will only naturally dry up sooner or later. For example, the oil reserves-to-production ratio is 44 years, as shown in Table 1. The figure 44 is the result obtained by simply dividing the proved recoverable reserves by the annual production. The reserves can increase if new oil fields are discovered in the future. However, recently frequency in the discovery of oil fields is rapidly decreasing, and the scale of newly-discovered oil fields is becoming smaller. On the other hand, the oil production is on an increasing trend. Accordingly, if the situation goes on like this, oil will probably become depleted in the middle or the latter half of the 21st century.

"If oil dries up, we will be left with an abundance of coal," some readers may say. Indeed, the coal reserves-to-production ratio is over 200 years, which seems to be quite sufficient. However, '211years' is the result calculated from the present production. If oil and natural gas dry up and coal is substituted for them in the future, the life span of coal will suddenly be shortened.

I can briefly summarize the crises predicted in the near future as follows. As human activities have been increasing at an accelerated pace on this finite earth, both the amount of natural resources exploited from the earth and the amount of waste discharged into the environment have been increasing rapidly. With reference to Fig. 2, this can be explained in the following way. The size of the circle which shows the earth is unchangeable; however, the arrows showing the exploitation of resources and the discharge of waste are increasingly thickening. Many experts warn that if effective measures are not adopted as things are now, a catastrophe will come within the 21st century. That is to say, it is feared that a very great number of people will be left with scarce resources on this finite earth where serious changes are caused by human activities.

Science Based on the Finiteness of the Earth

We have to control our activities immediately so that they balance with this finite earth. Accordingly, ‘environmentology’ can be defined as follows: “a systematized science whose purpose is that human beings control their activities appropriately on this finite earth.” The phrase “on this finite earth” means that we need to understand the earth and the natural environment; therefore, the fields of study including geophysics, geochemistry, climatology, biology, and physical geography are necessary. In reference to “human beings,” sciences which help understand humans, such as anthropology, primatology, brain science, cognitive science, and philosophy are necessary. The term, human “activities,” requires history to enter into environmentology because tracing human history brings us useful knowledge about human activities.

Moreover, in order to “control appropriately,” first, we must grasp the “appropriate condition.” This requires clarifying environmental changes caused by human activities as well as influences resulting from these environmental changes on human society; therefore, history, geography, chemistry, climatology, biology and medical science are necessary. In addition, understanding natural resources for human activities needs a discipline like a science of natural resources which deals with both renewable resources and nonrenewable resources. Finally, the requirement, “controlling” human activities, has two aspects: technological and social. The technological aspect means technology for environmental preservation, so it needs agriculture, fisheries, and a variety of engineering such as mechanical engineering, civil engineering, architecture, energy engineering, and applied chemistry. On the other hand, the social aspect is related to changing people’s awareness and behaviors as well as social systems, so it requires disciplines of study such as pedagogy, ethics, the science of information, politics, economics, and law.

In this way, environmentology involves a variety of disciplines of study, and in this systematized science, relationships among these disciplines are completely different from the present situation shown in Fig. 1a. Disciplines relating to environmentology are, as shown in Fig. 1b, closely linked to one another under the researcher’s clear intention to control human activities appropriately.

Chapter 2

Knowing the Earth:

Tracing the History of the Earth and Life

The Earth Viewed from Space

Mr. Toyohiro Akiyama, the first Japanese space pilot, published the book entitled "*Space and the Earth*" in 1999. The beginning of this book vividly describes how he was fascinated with the view of the blue glistening Earth from the Mir, a space station of the former Soviet Union, in 1990. The passage that expresses the delicateness of atmosphere covering light blue seas and green lands is particularly impressive.

"How thin the atmosphere covering the earth is! The bright and cobalt-blue layer has a thickness of only about 20 km above the ground. The atmosphere covering the earth 12,800 km in diameter looks like the film of a soap bubble."

The present earth seems to keep its balance with the ground, atmosphere, seas and life. However, traced back to remote antiquity, the state of the earth was completely different from the current one. Tracing the history of the earth and life, this chapter will deepen the understanding of the earth which is the very foundation of our life.

The Birth of the Solar System and the Formation of the Earth

About 4.6 billion years ago, near the edge of the Galaxy, an interstellar cloud which consisted of gas and dust started shrinking slowly. The shrinkage accelerated as the cloud became denser. Gradually the central part heated up and grew more brilliant. In this way, the protosun was born.

As the protosun grew, around it, the planet cloud which consisted of dust and gas was formed. This planet cloud collapsed into a thin disk. Everywhere in this disk, local concentration occurred. First, dust particles accumulated by gravity and formed ever-larger bodies named planetesimals. According to experts, around the present earth's orbit, nearly 10 billion planetesimals about 10 km in diameter formed. Moreover, these planetesimals repeatedly collided and combined with one another and grew larger at an accelerating rate. In this way, the proto-earth was formed.

Each time planetesimals collided against the proto-earth, volatiles that were contained in

both the earth's surface and planetesimals evaporated. The gas resulting from the volatiles floated over the ground and its density gradually increased. According to a computer simulation, main constituents of the atmosphere at that time were extraordinary: the atmosphere of water vapor was about 100 atm. and that of carbon dioxide was several tens atm.

From Magma Oceans to the Water Planet

Since planetesimals collided against the proto-earth one after another, the kinetic energy, that the planetesimals stored, converted into heat and therefore the temperature of the earth's surface gradually rose. In addition, the warming effect of the primitive atmosphere increased the ground temperature. While the greenhouse effect of carbon dioxide is well-known, in fact the greenhouse effect of water vapor exceeds that of carbon dioxide. As a result, rocks melted and therefore magma oceans covered the earth's surface.

After a while, as the number of planetesimals colliding against the earth decreased and the released energy also decreased, the ground temperature gradually dropped. As a result, vast water vapor in the atmosphere started condensing into water and fell as a severe rain. Thus primitive oceans were born.

After the water vapor converted into rain and fell, the main component of the atmosphere was the remaining carbon dioxide. Thereupon brand-new oceans absorbed carbon dioxide, so carbon dioxide concentrations sharply dropped to a level of about 10 atmospheres. Consequently the greenhouse effect decreased and the ground temperature fell to about 130°C.

When the ground temperature fell to this level, the earth's surface turned to rigid plates and plate tectonics began to function. Oceanic plates which formed at mid-ocean ridges traveled horizontally at an extremely slow speed and finally sank into mantle. The crust on the oceanic plate is low in temperature because it contained sea water. Therefore, the crust partly melted to turn to granite and climbed up to the earth's surface. With this process, continents were gradually created on this earth.

The Beginning of Life

About 4 billion years ago, when continents began to appear, a new breakthrough occurred in the ocean. That was the beginning of life.

The likeliest place where life was formed was hydrothermal vents, which are now also found at mid-ocean ridges. From hydrothermal vents, heated mineral-rich water flowed. So water around them had a high content of deoxidized gases such as methane, hydrogen and hydrogen sulfide, as well as metal ions including iron and magnesium ions. First, heated water

of about 350°C acted as a promoter to form these minerals into amino acids and nucleic acid bases. Next, these low molecular compounds changed to synthesize protein and nucleic acids. Moreover, as these high molecular compounds had metabolism and self-reproduction, they developed into the primitive life. However, there is no direct evidence to prove these chemical changes; therefore, the above process is only speculation.

The Appearance of Photosynthetic Organisms

After the beginning of life, no later than 3.5 billion years ago, quite highly evolved prokaryotes appeared. Meanwhile, the habitats of organisms that were at first located around hydrothermal vents gradually spread to the whole oceans. However, no organisms could live in the surface layer of oceans where high-energy particles from the sun passed through.

2.8 or 2.7 billion years ago, an evolutionally change happened. The barrier of strong magnetic field surrounded the earth and prevented high-energy particles from the sun from reaching the earth's surface. As a result, some organisms advanced to the top layer of oceans and started photosynthesis in which solar energy was utilized and oxygen produced. Oxygen emitted from photosynthetic organisms bonded with iron ions which existed abundantly in the oceans at that time. The compound, iron oxide, sank and accumulated on the ocean floor; this accumulation resulted in forming banded-structure iron ore layers all over the earth. Incidentally, these layers correspond to iron ore deposits which have been supplying a lot of iron to industrial societies.

The Appearance of Eukaryotes and Multicellular Organisms

After photosynthetic organisms oxidized all of iron ions in oceans, the amount of oxygen which dissolved in ocean water increased. This meant that the environment surrounding organisms changed drastically.

Originally, oxygen was highly poisonous for organisms because it could oxidize them and lead to their death. Thereupon, organisms changed the structure of their own cell, about 2.1 billion years ago. To be concrete, they produced a eukaryotic cell, which had a nuclear membrane within so that the membrane stored DNA inside and prevented it from being oxidized.

Eukaryotes utilized oxygen and could produce powerful energy by oxidation reaction. Therefore, eukaryotes grew larger, as compared with prokaryotes. As a result, multicellular organisms appeared around 1 billion years ago.

After the appearance of multicellular organisms, as the number of the cells that composed

their bodies increased, striking changes occurred in their shapes. Early changes were relatively simple; for example, the cells linked together in the form of a line or a sheet. Later, more complex changes occurred. For instance, sheet-shaped organisms changed to form the shape of a bag and had an internal space. Moreover, their shapes were remarkably diversified; at the same time, specialization of their cells progressed. As for animals, the cells of an individual were specialized to play a variety of roles such as eating, digestion, circulation, respiration, muscular movement, information gathering, information transmission, and information processing.

The above changes occurred dramatically in the Cambrian Period, which lasted about from 540 to 500 million years ago. Most of present zoological classification, for example, arthropods, mollusks and chordates, appeared in this period. This phenomenon that biodiversity increased suddenly is called “the Cambrian explosion.”

There was an unprecedented characteristic that some Cambrian animals had, that is, the existence of tests or spines on their body surface. This means that these animals needed protection from external enemies, in other words, animals which ate other animals, or predators, appeared in this period. The emergence of predators produced a variety of ‘predation’ relationships in the biological world and made the ecosystem more complex.

Formation of the Ozone Layer and Advance of Organisms to Land

When predators increased and the ecosystem became more complex in oceans, the remaining undeveloped territory for organisms was “land.” Land at that time, where ultraviolet rays from the sun beamed down, was a place that organisms could not advance to even if they wanted.

This situation changed about 450 million years ago. As the atmospheric oxygen concentration increased, the ozone layer was formed in the stratosphere. This change first allowed mosses which evolved from algae to appear on land. Next, arthropods such as centipedes came ashore and later formed simple ecosystems with plants in wetlands.

The landscape changed dramatically in the Devonian period, which lasted from about 410 to 360 million years ago. Ferns widely covered the land; plants whose height reached 20 meters appeared. Insects evolved out of arthropods and diversified within a short time. As for vertebrate animals, amphibians which evolved from fish came ashore.

In the next period, the Carboniferous, which lasted from 360 to 290 million years ago, flora and fauna widely spread over land and shaped large-scale and complex ecosystems. Plants especially grew thick in low latitudes under the temperate humid climate of this period. After growing abundantly, trees withered and fell down to marshlands. Fallen trees got buried, fixing

atmospheric carbon dioxide of that time. Later the fallen trees decomposed and carbonized little by little transmuting into coal. Incidentally, not only coal but also oil and natural gas formed from the remains of organisms which lived during the past several hundred million years; therefore, they are called “fossil fuels.”

Fig. 3: The chronology of the history of the earth and life

Era	Period	Million y. ago	History of the earth	History of life
Priscoan		4,600	Formation of the earth Magma oceans Birth of oceans	
		4,000	Appearance of continents	Origin of life
Archean				Earliest fossil of prokaryotes
			Barrier of magnetic field	Beginning of photosynthesis
		2,500	Accumulation of iron oxide	
Proterozoic			Increase in atmospheric oxygen	Appearance of eukaryotes
		1,900	First supercontinent	
				Birth of multicellular organisms
		540	Rapid increase in atm. oxygen	
				Rapid increase in biodiversity
		500		Oldest vertebrate animals
Paleozoic	Cambrian			
		440	Formation of the ozone layer	First organisms went ashore
	Ordovician	410		
	Silurian	360		First vertebrates went ashore
	Devonian	290		
	Carboniferous	250	Long-term environmental change	Mass extinction Birth of dinosaurs and mammals
	Permian	210		
Mesozoic	Triassic	150		Appearance of angiosperms
	Jurassic			
		65	Collision of a giant meteorite	Extinction of dinosaurs Rise of mammals
	Cretaceous	18		
				Origin of humans
Cenozoic	Tertiary			
	Quaternary			

The earth and life interacted and evolved.

Prosperity and Extinction of Dinosaurs

After conquering the land, organisms evolved the way they should. However, about 250 million years ago, at the end of the Paleozoic era, a long-term abnormal environmental change hit the earth and led to the largest-scale extinction of organisms in the earth's history. However, surviving species filled the void in the ecosystem by increasing by leaps and bounds. In addition, new species were born in the latter period of the Triassic (from 250 to 210 million years ago). The earliest mammals appeared; turtles, crocodiles and dinosaurs emerged from the reptiles. Among these animals, it was the dinosaurs that showed an overwhelming presence throughout the Mesozoic era.

Dinosaurs varied in their shape, size and feeding habits. In particular, herbivorous dinosaurs were remarkable for their size; individuals of the most large-sized species were 30 or 40 meters long and weighed as much as 50 tons. Moreover, primitive birds like archaeopteryxes, which could fly, appeared.

Dinosaurs, which had flourished spectacularly in the Mesozoic era, approached their end. With an exception of a group of birds, they became extinct about 65 million years ago. The most likely cause was that a giant meteorite whose diameter was as large as 10km collided with the earth.

After organisms including dinosaurs became extinct at the end of the Mesozoic era, surviving species thrived again. In particular mammals increased explosively. These mammal groups included primitive primates that were the earliest ancestor of human beings.

The next chapter will trace the history of humans who evolved from primates and moreover try to approach the secret why human activities have led to the explosive increases of today.

Chapter 3

Human-beings and their Activities:

Tracing Human History

Chimpanzees and Humans

Chimpanzees can use simple tools. They move on the ground with a *knuckle walk*. (Photographed by the writer at Tama Zoological Park in Tokyo)

Chimpanzees are the nearest animal relative to humans. A comparison of the DNA of both animals shows a difference of only about 1%. Chimpanzees have high intelligence and skill with their hands. In this picture taken in a Tokyo zoo, the chimpanzees are inserting twigs into an artificial mound made to look like an anthill and licking the juice that has been put in it.

However, in observing chimpanzees, we can easily find not only similarities to but also differences with humans. The obvious differences are posture, gait, and the length of body hair. Moreover, it seems that the situation under which chimpanzees have remained on the earth is the opposite to that of humans. In zoos, chimpanzees are only one of many species of animals that are kept in captivity and exhibited by humans.

Wild chimpanzees are also in a totally different situation from human beings. Wild chimpanzees live in the tropical rain forests of Africa; however, the population is decreasing due to exploitation and excessive hunting by humans. The International Union for Conservation of

Nature and Natural Resources (IUCN) lists the chimpanzee as “Endangered,” on the Red List of threatened species. In contrast, the number of human beings exceeded 6 billion in 1999 and it is still rising.

Although chimpanzees are the closest relations of humans, their situation on the earth is in stark contrast to that of humans in many ways. Then, we must ask ourselves, what is the most essential difference between the two species? Finally, this brings us to the eternal question, namely “What is a human?”

In this chapter, I will provide an answer to this question and explain why human activities have reached such an explosive increase today.

The Birth of Hominids

The common ancestor of humans and chimpanzees once inhabited the African tropical rain forest. About 6 million years ago, the species divided into two, and each of them started to evolve separately. The powerful hypothesis that explains the cause of this bifurcation is known as the “East Side Story,” which was first proposed by Yves Coppens, a French anthropologist.

About 8 million years ago, a violent diastrophism occurred on the African continent. It formed a huge rift and a wall that cut across eastern Africa from north to south. This change in geographical features separated the ecosystem of Africa spatially, and created great differences between the vegetation of the west and that of the east. To the west of the Great Rift Valley, the tropical rainforests remained; therefore, our common ancestor adapted to this wet, wooded environment. The descendants of this common ancestor are the chimpanzees that live there today.

In contrast, to the east of the Great Rift Valley, the climate became dryer and dryer. As a result, the forests became smaller and the grasslands expanded. In this open land, a pattern of movement that adapted to life on the ground was advantageous. As a result, a primate that walked upright, or hominid, was born.

Revolutionary Changes Caused by Walking Upright

After the primitive African hominids began walking upright, their body changed strikingly. The most remarkable change was that the volume of their brain increased rapidly.

There were two reasons for this increase. First, there was a change in the structure of the body. Because the hominids stood upright, their skull was positioned right above their backbone; therefore, the hominids could bear the weight of a heavier head.

The other cause was that the hominids used their brain more actively than before. Since the

hominids stood upright and could use their hands freely, they handled tools more frequently. In the beginning, their tools were mere stones or sticks for hunting and gathering. Afterwards, *Homo habilis*, who lived in Africa between 2.5 and 1.5 million years ago, made stone implements. Later, *Homo erectus*, who lived in Africa and Eurasia between 1.8 and 0.5 million years ago, made simple houses and clothing, and used fire. In this way, moving their fingers stimulated their brain function and increased the volume of their brain.

In parallel with the improvement of manual dexterity, group communication became more active. Situations where hominids had to recognize each other's intentions increased. For example, they allotted the roles of hunting or gathering among themselves, and also shared the animals and plants that they obtained. At the same time, since standing upright lowered their larynx and extended their pharynx, they could utter various phonetic sounds. In these processes, simple phonetic signs were born, and the signs were systematized into language. Furthermore, active communication stimulated their brain function and increased the volume of their brain.

As can be seen, walking upright caused several changes: the growth of brain, the development of manual dexterity, the use of tools and fire, the development of the faculty of speech, and the increasing complication of society. Moreover, each factor stimulated others and promoted changes in other factors. As a result of these synergistic effects, "human beings," animals clearly distinguished from others, were born.

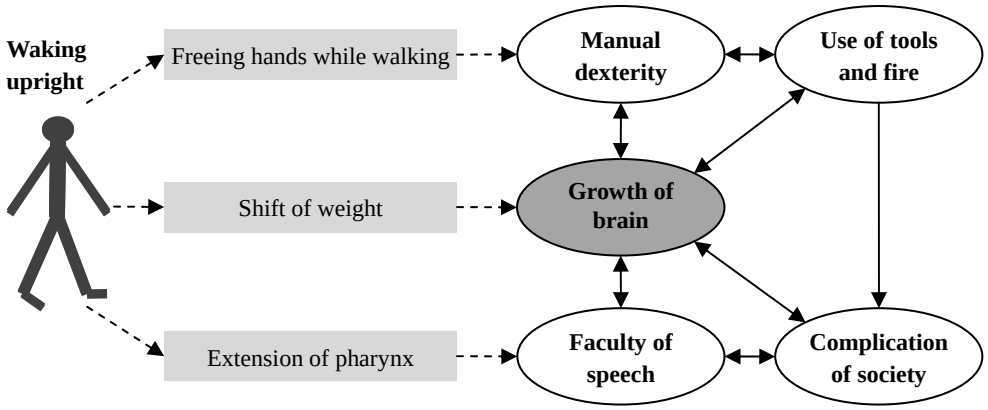


Fig. 4: Revolutionary changes caused by walking upright

Redefinition of a Human

Then what is the most essential distinction between humans and the other animals? In this regard, I have arrived at a solution by synthesizing current scientific knowledge. The details have been explained in my book *An Introduction to Environmentology*, so the following describes only the conclusion.

Humans are conscious of the purpose of their acts, when they influence not only the natural environment by using their hands but also the social environment through using language. By contrast, the other animals, including chimpanzees, do not have such abilities. In other words, the essential attribute of humans is that they can influence the natural environment and the social environment with a sense of purpose. Accordingly, when the word *environment* is recognized as a concept including both the natural environment and the social environment, my definition of humans is as follows: humans are animals that can influence the environment with a sense of purpose.

The Worldwide Spread of Homo sapiens

Hominids eventually evolved into *Homo sapiens*. *Homo sapiens* appeared about 150,000 years ago in Africa, where the primitive hominid was born.

About 100,000 years ago, *Homo sapiens* left Africa and spread all over the world. The course and time of the spread is estimated as follows. *Homo sapiens* advanced through south Asia and arrived in Australia between 50,000~60,000 years ago. They also reached Europe about 40,000 years ago and Siberia about 30,000 years ago. Furthermore, they walked across the Bering Strait, which was frozen in those days, and appeared on the North American Continent over 10,000 years ago.

Homo sapiens, which today's people belong to, had excellent abilities to influence both the natural and social environment. They influenced the natural environment, using their superior techniques shown by their use of elaborate tools. On the other hand, they influenced their social environment, employing an epoch-making invention in language called "double articulation." Double articulation means that a sentence consists of words, and moreover, a word consists of 'phonemes,' for example, the sounds *b* and *p* in the English words *bad* and *pad*. This duality of structure brought unlimited possibilities of expression to languages. Therefore, group communication for *Homo sapiens* became remarkably smooth and they could cooperate closely with one another.

As a result, for instance, their hunting improved strikingly, and the pressure of their hunting on wild animals could exceed the reproduction capacity of those animals. In fact, in the Eurasian Continent and the American Continent where *Homo sapiens* advanced, overkill exterminated many species of large-sized animals including the mammoth.

About 10,000 years ago, by the time the great migration of *Homo sapiens* reached the southern end of the South American Continent, they had spread over almost all areas on the earth. The world population of those days is estimated at approximately 5 million. This figure might be regarded as the maximum population that a hunting and gathering society could

support. In this way, the relationship between human beings and the natural environment grew more strained than ever. However, there was no more land to which *Homo sapiens* could advance. Therefore, they had no choice but to extract more food from the natural environment by using new techniques, in order to feed their growing population. This pressing situation produced revolutionary methods of food production, namely agriculture and livestock farming.

The Farming Era

Agriculture and livestock farming, which started about 10,000 years ago, greatly increased yield per unit area and moreover rapidly augmented populations. The production of food, especially grain, yielded surpluses which increased the number of people who did not have to directly engage in farming. As a result, the governing classes, the clergy, technical workers, and intellectuals appeared. These non-farming workers basically invented new skills and techniques in quick succession. Among these inventions, a *writing system* has exerted the biggest influence upon the course of human history.

The greatest significance of the advent of writing was the storage of information. Previous people could keep information only in their brains as memories; however, writing enabled them to retain information in various places as records. Consequently, people could easily add new knowledge to existing knowledge passed down by their ancestors.

Particularly after the 15th century, the spread of paper and printing throughout Europe accelerated the accumulation and spread of knowledge. This rapidly growing knowledge stimulated technological advances and quickened industrial development. As a result, the depletion of forests became a serious problem in Europe. Throughout the farming era, firewood and charcoal were indispensable fuels for not only households but also industry. Wood was also a significant raw material for various products such as houses, bridges, ships, carts, and containers. Therefore, reckless deforestation was evident in Europe from the 11th century. In addition, the iron industry, which developed after the 16th century, made the shortage of wood even more serious.

When people were confronted with the depletion of forest resources, it was also new technology that finally solved the problem. Above all, the invention of innovative iron-manufacturing technology and the steam engine enabled the use of coal instead of wood, and led Europe into the Industrial Revolution.

The Industrial Era

Fuel was converted from wood to coal, and the basic raw materials for construction and

products changed from wood to iron. These conversions removed restrictions on energy and raw materials. As a result, the Industrial Revolution started on a full scale, and the influence of human beings on the natural environment reached a new phase.

In the 19th century, railroads and large power-driven ships became widespread and began to transport a large quantity of goods quickly and steadily. The efficiency of food production rose; populations increased rapidly. Steel-frame buildings and engineering works were constructed; reinforced concrete constructions started to appear. Moreover, motor transportation and aerial transport, both of which expanded explosively in the 20th century, conveyed people and goods more rapidly and extensively.

In addition to people and goods, the flow of information changed dramatically in the industrial era. First, technological innovations in papermaking and printing rapidly increased the publication and circulation of books, newspapers, and magazines. Next, a technological revolution in electrical communication added astonishing changes. Telecommunications equipments such as the telephone, the radio, and the television were invented, and in the 20th century their popularity grew exponentially.

A surge in the amount of information and quick acceleration in information transmission speed directly and indirectly exerted a great influence on economic activities. The accelerated accumulation of knowledge increased the frequency of scientific discoveries and technological inventions. In addition, with the advent of commercial advertising, information was utilized for the sales promotion of all possible goods such as foods, clothes, electrical appliances, and cars. As a result, in the 20th century, business enterprises produced not only merchandise but also consumer desire.

Historically, human beings increased their influence on both the natural environment and their social environment synergetically; as a result, human activities expanded in a geometric progression. On the way to this expansion, although human beings were confronted with

Table 2: Chronological table of human activities classified by stages

Stage	**Period**	**Food**	**Products** (clothes,buildings,transportation)	**Energy**	**Information**	**Population**
World spread of Homo Sapiens	100,000 ~ 10,000 years ago	Hunting Gathering	Hide Simple houses made of branches and hides Sledges and boats	Human power Biofuel (firewood etc.)	Double articulation	Small increase
Farming era	10,000 years ago ~ the latter half of the 18th century	Agriculture Livestock farming	Natural fiber Built of clay, stone and wood Carts and sail boats	Livestock Hydropower Wind power Biofuel (charcoal)	Writing	Rapid increase
Industrial era	From the latter half of the 18th century	Intensive agriculture	Synthetic fiber Steel-frame structure reinforced-concrete structure Railway, power vessels and motorcars	Coal, oil and natural gas Nuclear power	Mass-production and high-speed communication	Sharp increase

restrictions on food, raw materials and energy, they overcame the restrictions with technological innovations. Consequently, human civilization has come to realize the amazing prosperity of today.

However, in parallel with such development, harmful influences exerted by human activities have also unexpectedly increased. In the next chapter, I will trace the history of environmental problems after the Second World War and show the “visions” that we should share in our present global environmental era.

Chapter 4

A Vision of our Global Environmental Era

Overlooking the Metropolitan Area from 202 Meters above Ground

This picture is a view of the Metropolitan area as seen from the observation deck of the Metropolitan Government Office building in Shinjuku, Tokyo. The spectacle where large and small buildings range endlessly and innumerable cars are coming and going is the gigantic product of amazing economic growth in postwar Japan.

The view of the Metropolitan area stretching as far as the eye can reach. (Photographed by the writer from the observation deck on the 45th floor of the Tokyo Metropolitan Government Office building)

However, looking at this view, I am swayed by misgivings. In the 21st century when global warming will worsen and fossil fuels will be exhausted, can we maintain this extremely

overcrowded megalopolis? A more urgent problem is that all products of this civilization, even the great edifices, will outlive their usefulness and gradually change into waste. When we are unable to manage waste as it is now, how can we deal with a situation in which “the whole city turns into waste?”

Moreover, is it really comfortable for people to live here? In this overpopulated and congested area, we can hardly find the space for children to play or adults to rest. It seems that people are pressed for time and suffer stress from an infinite range of goods and information.

Now, we have to thoroughly reconsider our activities. In this chapter, reviewing Japanese postwar economic growth and its harmful influences, I will clarify the ‘goal’ that we must share in the future.

From Postwar Rehabilitation to High Growth of the Economy

In 1945, during the last period of the Second World War, major Japanese cities were repeatedly attacked from the air and fell into ruins. For quite a while following the defeat, starvation and malnutrition distressed people. The production of the mining and manufacturing industries dropped sharply from the prewar level.

It was in 1955 that the level of production and consumption recovered to the prewar level. Afterwards, the Japanese economy entered an unparalleled growth process. The chief industries drastically switched from agriculture to manufacturing. At the same time, the population rapidly concentrated in urban areas.

In addition, people’s lives as consumers suddenly changed. Dishes of meat, eggs and processed food were added to their dining tables. Each household in the country suddenly had durable consumer goods such as televisions, refrigerators and washing machines. A subsequent change was the advent of motorization. In 1966, automobile transportation surpassed railroad transportation for both passengers and freight. Roads were paved in quick succession, and expressways were constructed one after another. The number of households possessing cars increased dramatically.

High Frequency of Pollution Problems

While Japanese people were elated by the high growth of the economy, its harmful influences increased rapidly.

First, the destruction of nature caused by land development came to be realized. In coastal industrial zones, beautiful shorelines disappeared due to the construction of large-scale harbor facilities and factories. Disorderly residential development destroyed the forests on the outskirts

of large cities. Furthermore, everywhere highways were constructed, nature all over the country was destroyed along the line of highways.

The pollution of the environment followed the destruction of nature. Rivers, seas, lakes and marshes became impure and emitted foul smells because of the liquid waste from factories and households. The water was contaminated by toxic chemical substances such as mercury, cadmium, arsenic, PCB (polychlorinated biphenyl) that were contained in the liquid waste from factories. The ground was covered with the soot and the smoke from the chimneys of factories and thermal power stations. In many large cities, photochemical smog frequently occurred due to fumes from cars.

Some of these environmental contaminants damaged human health seriously; therefore, they became issues of profound public concern. Organic mercury compound poisoning caused "*Minamata* disease" in Kumamoto and Niigata Prefecture, and cadmium poisoning caused "*itai-itai* disease" in Toyama Prefecture. These water pollution issues resulting from industrial waste attracted a great deal of attention even overseas because of devastating damage. Concerning the atmosphere pollution resulting from factories, respiratory diseases such as *Yokkaichi* asthma occurred around the petrochemical complexes turned into grave social issues. Moreover, car fumes caused respiratory diseases; along highways in large cities, the symptoms became more severe due to the additional influence of noise and vibration.

Although pollution problems changed for the better, production and consumption expanded

As pollution problems became serious, the people's voice and movements for anti-pollution measures increased day by day. As a result, the Japanese Government imposed legal controls on contaminants from factories and facilities. Laws such as the Fundamental Anti-pollution Act (1967), the Atmospheric Pollution Prevention Act (1968), and the Water Pollution Prevention Act (1970) were enacted and revised; the environmental standards for each contaminant and the standards of discharge of those contaminants were provided. In addition, exhaust restrictions that were aimed at reducing poisonous substances in car fumes such as carbon monoxide, nitrogen oxide and hydrocarbons started in 1974.

With the enforcement of regulations and the efforts to achieve them, such serious environmental pollution gradually changed for the better. In this period as the atmosphere and water were being restored to purity little by little, people supported the strict regulations and welcomed the earnest efforts of industry. In addition, most people had a sense of security that "the environmental problems had been resolved." At the same time, another situation developed, that is, the economic tendency to mass-produce and mass-consume accelerated at a faster pace.

The chemicals that caused pollution problems were waste and by-products that were discharged from production processes or from driving cars. Therefore, while the discharges of these toxic substances were checked, the production and the car-driving itself was permitted and often promoted. Regarding thermal power stations and petroleum refineries, when the pollutants such as sulfur oxide and nitrogen oxide were removed by means of desulfurization and denitrification equipment, the health of the neighborhood was protected. However, energy production itself was accepted and the utilization of fossil fuels was often furthered. Concerning production in factories, anti-pollution measures could purify exhaust gas and liquid waste, but the purification of them could also allow companies to produce more and more goods. Moreover, purifiers could remove toxic substances from car fumes and prevent automobile pollution. However, car-driving itself was allowed and cars increased in number.

In the 1970s and 80s, this very such situation occurred. The number of car in Japan increased rapidly. The goods that symbolized wealth such as microwave ovens, video tape recorders, compact disc players, video game machines, satellite broadcasting, drying machines, and multi-function telephones, gained in popularity one after another. Also energy usage steadily increased except for the two periods immediately after the oil crises in 1973 and 79.

Problems caused by mass production and consumption

In around the 1980s, when mass production and consumption became a part of the culture, problems that people could not imagine or did not confront boldly began to surface one after another. These problems can be divided into three groups: (1) “global environmental problems” typified by global warming, (2) “local environmental problems” such as an increase in waste, (3) so-called “diseases related to civilization.”

(1) Global Environmental Problems

With the breakdown of the Cold War structure in the latter half of the 1980s, when advanced countries including Japan were relishing material prosperity, the world perceived new crises. Global environmental problems, for example, global warming, ozone layer destruction, tropical deforestation and decreasing biodiversity came to light.

(a) Global warming

The principle cause of global warming is carbon dioxide (CO_2) that is mainly emitted by the combustion of fossil fuels. Since CO_2 itself is directly harmless to the human body, people were unconcerned about these emissions. Therefore, vast CO_2 has accumulated in the atmosphere. It is feared that global warming causes the rise in sea levels and the increase of abnormal weather.

(b) Destruction of the ozone layer

Ozone in the stratosphere has been mainly destroyed by chlorine from chlorofluorocarbons (CFCs). As CFCs have superior chemical behavior for industrial use as well as no ill effects on the human body, they were used in large quantities. It is well known that destruction of the ozone layer increases the short-wave ultraviolet rays reaching the ground and has a harmful influence on organisms.

(c) Destruction of Tropical Rainforests

Destruction of tropical rainforests has been caused by lumbering for timber and firewood, and development utilizing cutover areas. Japan imported a great quantity of wood from a tropical area especially for producing plywood. In other words, Japan destroyed tropical rainforests, while excessively preserving the forests in its own country. Furthermore, a decrease in biodiversity has been caused mainly by the destruction of tropical rainforests which are rich repositories of wild organisms.

(2) Local Environmental Issues

Mass production and consumption has inevitably increased waste. In addition, “heat islands” have progressed in large cities.

(a) Increase of Waste

All artifacts, for example, buildings, roads, cars, electrical appliances and containers, are produced, used and finally turned into waste. Waste also comes out of production processes. Increase of waste has already been a serious problem. Yet, this problem will inevitably become more serious hereafter because a huge number of products will have reached the end of their life span in this country. Furthermore, we are also confronted with other difficulties such as the disposal of radioactive waste from nuclear power generation and dioxin generated by the process of burning waste.

(b) Heat Islands (Urban Warming)

In large cities, “heat islands” have progressed remarkably. Main causes of a rise in urban temperature are the use of vast energy and land development which destroys vegetation and therefore decreases evaporation from plants.

(3) Diseases resulting from Civilization

The rapid economic growth after the middle of 20th century has made the human environment drastically and chaotically artificial. This ‘excessive and inappropriate artificial environment’ has a harmful influence on our bodies and minds. A typical example of this is a traffic accident; in addition, obesity, stress diseases, allergies and sleep disorders have been increasing recently.

(a) Obesity

Plentiful food and lack of exercise has caused an increase in the number of overweight people. As a result, the incidence of diabetes, hypertension, hyperlipemia are on the rise.

(b) Stress Diseases

Modern society is stressful because it changes rapidly and becomes complicated. People tend to lose their mental balance, always pressed for time and become tense in daily life. They often suffer from depression, neurosis and psychosomatic diseases.

(c) Allergies

Cases of allergic diseases such as atopic dermatitis, bronchial asthma and hay fever are increasing. Main causes of this increase are considered to be excessive food, atmospheric pollution and stressful lifestyles.

(d) Sleep Disorders

Cases of sleep disorders are increasing because of stressful life and lifestyles offset from the normal cycle of day and night. Statistics show that about one of five Japanese and one of three Americans suffer from sleep disorders.

Heading for Sustainability and Harmony

Mass production and consumption not only has caused various environmental problems but also has undermined our health. Now we have to make a complete turnabout and head towards a new goal. This goal can be expressed in these two keywords: “sustainability” and “harmony.”

The first keyword, “sustainability,” is closely related to the recognition that “the earth is finite.” This understanding was promoted with obvious global environmental problems in mind, and the term “sustainable development” was devised. The World Commission on Environment and Development defined “sustainable development” as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Our Common Future, 1987). After that, the term was widely accepted with the Earth Summit in

Table 3: Goal for human activities in the global environmental era

Sustainable use of the finite environment and resources [Sustainability] (H. Daly)
(1) The harvest rates of renewable resources should equal their regeneration rates.
(2) Nonrenewable resources can be exploited by limiting their rate of depletion to the rate of creation of renewable substitutes.
(3) Waste emission rates should equal the natural assimilative capacities of the ecosystems into which the wastes are emitted.
Optimizing relations between human activities and both ecosystem and society [Harmony]
(1) The influences of our activities on living things and physical environment should be considered.
(2) Safety and amenity of society should be maintained.

1992 as the turning point. Moreover, on the basis of this definition, a variety of principles for sustainable use of the finite environment and natural resources were laid down. A representative attempt of these is the three principles devised by Herman Daly, which are shown in Table 3.

The second keyword, “harmony,” requires us to optimize the relations between our activities and both ecosystem and society. In order to optimize the relation between human activities and ecosystem, we have to consider the influences of our activities on both living organisms and the physical environment. This point is extremely important, especially when buildings and engineering works are constructed. On the other hand, for optimizing the relation between human activities and society, safety and amenity should be maintained. For this purpose, the following examples are recognized as concrete objectives: a production system without releasing any toxic substances in all processes from manufacturing to disposal, a transportation system minimizing traffic accidents and pedestrians’ feeling of danger, and serene living conditions with much greenery.

In Chapter 1, I defined *environmentology* as “a systemized science aiming at controlling human activities to reach an optimum condition on this finite Earth. Now, this section has made clear that an ‘optimum condition’ in the above definition is equivalent to the state in which “sustainability” and “harmony” are both achieved.

The remaining task is to show ways to control human activities toward this ultimate goal. When controlling human activities, we can adopt two approaches: ‘technical’ and ‘social.’ In the next chapter, I am going to discuss the essentials of the technical approach with some concrete examples.

Chapter 5

Environmental Preservation Technologies

A Pavilion Built with Recycled Paper

In October 2000, I had a chance to visit Germany, which is known as an environmentally advanced country. At the beginning of this chapter, I will introduce two especially interesting observations from this overseas inspection trip.

The first was the Japan pavilion of Expo 2000 in Hanover City. When I stepped into the main hall of this pavilion, the whole space was filled with gentle light. The roofing material was waterproof and fireproof paper, and the role of this material was similar to *shoji* paper, traditional Japanese material for fittings.

As well as utilizing sunlight as lighting, recycling of the building materials was thoroughly considered. The major structural materials were paper tubes which were made of recycled paper collected in Germany. In addition, careful attention was paid to use materials so that they could be easily recycled after the pavilion was taken apart.

The Solar Factory

The building shown in the photographs is the Solar Factory in Freiburg City, located in the southwest corner of Germany. Since 1996, this factory has produced all components of the photovoltaic power generation system: solar cells, inverters, and installation hardware. The

The Solar Factory in Freiburg

distinctive feature of the Solar Factory is that solar energy alone supplies all of the energy that is used in this factory.

The entire south front of the building is covered with glass and solar cells. The solar energy passing through the glass decreases the demand for heating energy, and the solar cells transform sunlight into electricity. In addition, the energy supply is supplemented by a combined heat and power plant fueled by rape-seed oil which is produced in this region. The amount of CO_2 released when the rape-seed oil is combusted, equals the amount of CO_2 that the rape crops originally absorbed during the growth.

In this way, the entire energy needs of the Solar Factory are met by solar energy, namely, solar heat, photovoltaic power generation, and biofuel. Incidentally, this innovative endeavor brought several awards to this factory.

Guidelines for Eco-Friendly Production

After having shown my experiences in Germany, I will consider the production of environmentally friendly products from a variety of angles.

People produce and use products such as clothes, electrical appliances, cars, buildings and engineering works. The raw materials of these various products are divided into two groups; renewable resources typified by wood, and non-renewable resources such as metals. After products are used, useless products become waste. Waste also comes out of the production processes.

On the other hand, energy is necessary to produce goods. Energy is also necessary to use power machinery such as cars and electrical appliances. The sources of the energy are also divided into renewable and non-renewable. Radiation energy from the sun accounts for 99.98% of the renewable energy that is supplied to the earth's surface. The rest of the renewable energy is geothermal and tidal energy. The kinds of the non-renewable energy are fossil fuels and uranium which is used for the fuel of nuclear power generation. The burning of the fossil fuels discharges waste such as carbon dioxide and sulfur oxide; nuclear power generation discharges radioactive waste such as spent nuclear fuel.

Based on the flow of substances and energy shown above, guidelines for production which lead to 'sustainability' and 'harmony' are summarized in the following ten items.

(1) Extension of products' life span

In order to reduce resources for products, it is essential to extend the life span of the products by increasing their durability.

(2) Reduction in the amount of materials

This strategy means making high-performance products from less raw materials. The methods for reducing the amount of materials include improvement in the strength of materials, improvement in the form of structures, and the development of innovative technology.

(3) Utilization of organic materials

Organic resources are not exhausted as long as they are used within the capacity for reproduction of the organisms. In addition, when used products made from organic resources are burned, energy can be extracted.

(4) Consideration for reuse and recycling

The composition of products should be simplified or standardized so that the products can be easily reused and recycled. This consideration also leads to the ease of repairing the products.

(5) Control of toxic substances

Toxic substances must be controlled throughout the process of production, utilization and disposal.

(6) Design matched with humans and nature

Products should be designed to maintain the safety and amenity of human society as well as to minimize the influence on the ecosystem and the physical environment.

(7) Improvement in energy efficiency

When energy-using machines such as cars and electrical appliances or energy-converting machines such as generators are designed, it is essential to improve the energy efficiency of such products.

(8) Systematic use of thermal energy

When heat is used in a production process, the different temperature of the heat should be utilized as it cools. The combined heat and power system in the Solar Factory in Freiburg City is based on this idea. The high temperature produced by burning fuel is suitable for generating electricity. The remaining heat after the electricity generation is also useful; therefore, it can be used for various processes in production, heating, and hot-water supply.

(9) Passive use of renewable energy

This strategy means utilizing renewable energy without installing mechanical devices. A

typical example of this is the direct use of solar energy for lighting or heating, which was adopted at the Japan pavilion of Expo 2000 and the Solar Factory in Freiburg.

(10) Active use of renewable energy

This method means using renewable energy by means of some devices such as solar cells, windmills and hydroelectric power stations. The active use of renewable energy includes biofuel combustion. The plant fueled by the rape-seed oil in the Solar Factory is an example of this biofuel combustion.

In this way, designing eco-friendly products requires careful considerations from various angles. Moreover, the optimal design is flexible depending on the place or the environmental conditions where the product is made or used. In the next section, I will consider an ecological housing design, paying attention to relationships between the products and their environment.

Ecological Housing Design

Historically, the raw materials that a house was composed of were what people could easily find and obtain. Cases in point are stone or clay in dry regions and wood in rainy regions like Japan. Therefore, if people build a house in Japan, they should think of using wood first. Since wood is easy to process as well as strong for its weight, wooden buildings require less energy for construction compared with reinforced concrete or steel-frame buildings. In addition, wood stabilize indoor temperature and humidity; accordingly, it has a favorable influence on the body and mind of the occupants. Therefore, selecting wood as the building material is effective in improving both the indoor environment and the natural environment.

Surplus-energy houses in Freiburg City (Photographed by the writer)

Also observing a house from the viewpoint of utilizing energy, there are many ways to reduce an impact on the environment. An improvement in insulation and airtight performance can greatly save the energy needed for air conditioning. Moreover, if you use the technique of "passive solar," that is to say, the utilization of solar heat or sunlight without installing mechanical devices, you can save still more energy. Ingenious use of solar energy, for example, equipping the southern face of a house with large windows and the eaves whose depths are suitable for taking sunlight, can reduce energy for air conditioning and artificial light. In this connection, the passive use of solar energy is good for human health because it leads people to follow the natural cycle of day and night. In addition, if a house is equipped with solar panels or solar collectors on the roof, solar energy can cover the total energy demands of the house. For example, some Japanese manufacturers of prefabricated houses have built self-sufficient houses in energy by means of various devices for energy saving as well as solar panels. Moreover, in Freiburg City, surplus-energy houses, or houses generating more renewable energy than they consume, have been built.

In order to improve the relations between a house and its natural environment, it is important to consider the water cycle. If you store and use the rainwater on the roof, or if you allow it to infiltrate into the earth, this water cycle approaches a natural one, and floods can be prevented.

Furthermore, because a house is an important factor composing a city or a town, the influence on the landscape should be considered. The shape and the color of a house are required to match the existing row of houses.

Ecological City Design

Nowadays, cars have a serious impact on the surroundings and the global environment. All automobile manufacturers are making desperate efforts to decrease the environmental impact caused by cars. However, even if the car itself is improved, the continuous increase in the number of cars will have a detrimental effect on the environment. In the 21st century, transportation including road traffic should be changed to a situation that can realize both *sustainability* and *harmony* with humans and nature. Therefore, I will consider ecological city design and begin with the traffic problem.

In order to reduce the number of cars without decreasing the convenience of transportation, we can adopt the following approaches: modal shift, the reduction in distance for transportation, and carsharing system. Modal shift is the changeover to the eco-friendly means of transportation. To be more concrete, it is effective to convert passenger traffic from cars to public transportation and bicycles, as well as to convert freight traffic from trucks to rail or water

transport.

The reduction in distance for transportation means to bring the destination closer to the starting point. This strategy requires changes in the way of land-use planning; for example, in order to reduce cars for passenger traffic, it is effective to bring houses closer to the workplace or office, and to place public facilities nearer to the railway station.

Carsharing system is not owning a car but sharing the use of a car. As for distribution of goods and materials, joint collection and delivery can reduce the number of trucks. As for passenger transportation, there is a remarkable system called “carsharing,” which is becoming widespread in European countries, especially in Switzerland and Germany. Switching from car-owning to carsharing, you can drastically curtail expenditure.

If these measures can actually reduce the number of cars, the structure of roads is expected to change from a conventional roadway-centered way to a way that places priority to sidewalks and cycling paths.

In addition to buildings and transportation systems, public parks and green zones are also important elements composing a city. The planting of trees in cities has various functions, for instance, absorbing carbon dioxide, relieving the heat island phenomenon, normalizing the water cycle, and adding a pleasant atmosphere to a drab landscape.

Regarding urban greening and planting trees, it is essential to select appropriate species of plants. Previously, people tended to choose the sorts of plants that were favorable for them, for

Housing development decreasing cars in Freiburg City
In this housing development, the number of cars has been drastically decreased through methods such as the provision of public transportation and cycling paths, planning shops and offices in the same area, and carsharing. (Photographed by the writer)

example, plants with beautiful flowers and trees which require little maintenance. However, such human-centered planting is undesirable for wildlife because it deviates from the local ecosystem.

Currently this human-centered tree planting is being reconsidered. A sign of this reconsideration is a recent trend to create biotopes inside cities. A biotope, the region of a habitat associated with a particular ecological community, can often be found in school grounds or public parks. Moreover, in the future, we should increase green zones that respect the nature of local ecosystem, and link them together well in order to recover damaged biodiversity.

Resources in the 21st Century

In the 20th century, people frantically dug up underground resources and consumed them on a massive scale, using newly-developed technologies. By contrast, in the global environmental era, they have to develop technologies with a new understanding, that is, “resources exist on the ground.” When people search for energy resources, they are required to ingeniously harness renewable energy such as solar heat and sunlight, wind and water power, the energy of photosynthesis, and geothermal heat.

From this viewpoint, Japan is not poor in energy resources; on the contrary, it is very rich. Forest resources, which are important as material resources, can be found throughout this country. Furthermore, we can regard cities as a repository of material resources because innumerable buildings, engineering works, cars and other products have accumulated there. Therefore, hereafter it is necessary to make the best use of both renewable resources and used products or structures which have reached the end of their life span.

Technologies required in the global environmental era have been developing steadily. The remaining task is to encourage people to use these technologies as well as to choose eco-friendly behavior more actively. For this purpose, we need to institute social systems which promote changes in our behavior; and more fundamentally, it is necessary to cultivate our awareness and attitudes towards such changes. In the last chapter entitled “Change our Society,” I will tackle these important challenges.

Chapter 6

Change our Society

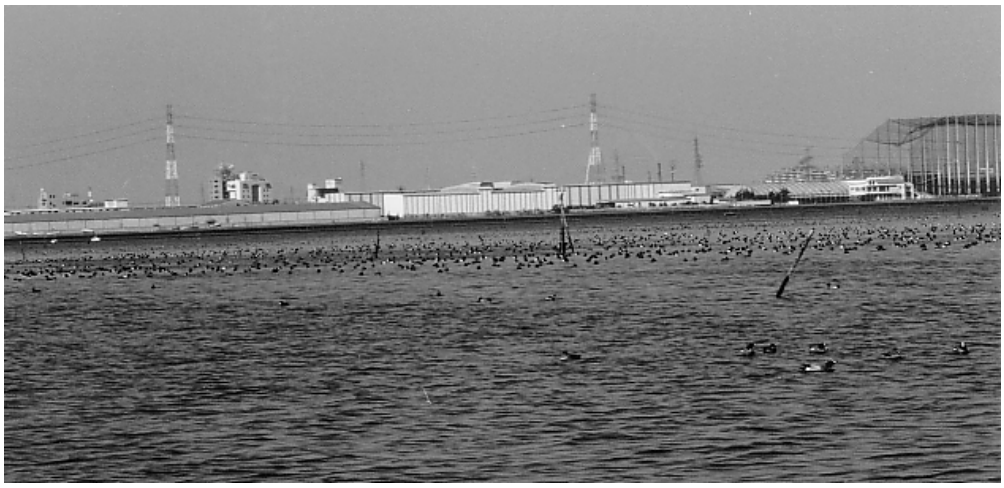
A Trend in Tideland Conservation in Japan

In April 1997, an area of 3,500 hectares was closed up at the inner part of *Isahaya* Bay in the Sea of *Ariake* that is well-known as a habitat of mudskippers. The scene of the sluice gates, which were like “guillotines” being slammed-shut in the water one after another, was repeatedly shown on TV and shocked many people. In addition, the media revealed the true situation that the purposes of the reclamation works were for farmland development and flood prevention but the people were not unconvinced. These media reports rapidly developed a groundswell of public opinion in favor of the preservation of nature as well as the reconsideration of reclamation works.

Changes in public opinions triggered by the reports on the reclamation works in *Isahaya* Bay influenced the reclamation plan of *Fujimae* Tideland. At the inner part of *Ise* Bay, the sea area lying between the *Nikko* and the *Shin* estuaries was almost the only unreclaimed tideland surrounded by reclaimed areas of land around Nagoya Harbor. This tideland was well-known as the place where migratory birds such as sandpipers and plovers came flying. In 1984, the Nagoya municipal authorities announced the plan that this *Fujimae Tideland* would be used as a landfill site. Since then, local people led by a citizens’ group continued campaigns against the reclamation. After that, the confrontation between the two camps became tense with two reasons: room for the final disposal site diminished and the reports about the destruction of *Isahaya* Bay continued.

The opposition group campaigned in various ways against the municipal authorities who attempted to force the reclamation. The group members built closer connections with researchers and nature-conservation groups through the Internet, which was rapidly becoming widespread in those days. They persistently appealed to members of the administration and assembly to discontinue the plan. Consequently, in January 1999, the municipal authorities abandoned the idea of the reclamation.

The tendency to conserve tidelands that became evident with the preservation of *Fujimae* as a turning point became more evident with the matter of *Sanbanze*. The innermost part of Tokyo Bay, a sea area lying close to the coast of Ichikawa and Funabashi Cities in Chiba Prefecture is called *Sanbanze.* In this tideland, about 600 species of organisms including birds



***Sanbanze* in Tokyo Bay** (photographed by the writer)

and fish live. At first, the Chiba prefectural authorities had planned to reclaim an area of 740 hectares; however, in 1999, the authorities announced the reworked plan that the reclaimed area would be reduced to 101 hectares. The purpose of the reclamation was to obtain a site for a sewage plant, factories and a highway which would run along the coast. However, persistent objections to this reworked plan were raised again; therefore, the people involved continue to reconsider the plan on the premise that the reclamation would not be undertaken at all.

Concerning the opposition to the reclamation of *Sanbanze*, there were also steadfast efforts and activities by local residents and civil groups. However, interestingly, in the case of *Sanbanze*, we observe a special relationship between the authorities and the opposition groups; at first the two parties confronted each other but now they work together. The local governments, nature-conservation groups and researchers are collaborating with one another to come up with the best way of land use and tideland conservation.

After shutting down the reclamation area of *Isahaya* Bay, the trend to conserve tidelands such as *Fujimae* and *Sanbanze* seems to show a shift in priority from development to environmental preservation. However, people are skeptical whether this shift is certain. For example, reducing road construction which heads the list of public works projects has hardly been considered. The movement for stopping global warming has also been sluggish since the 3rd Conference of the Parties (COP3), which was held in Kyoto in 1997.

Now is the time to accelerate great social changes in order to avoid future crises such as global climate change and depletion of natural resources, and realize a truly rich society. What should we do to make these changes happen?

Activities of Nonprofit Organizations

We are living in “democracy,” that is, a society in which sovereignty resides in the people. Democracy expanded all over the world through the 20th century, and it has been forecasted that this tendency will continue in the future. Therefore, in the 21st century we must find practical ways to achieve *sustainability* and *harmony* in democratic societies.

In democratic societies, governments perform administrative services which are paid for with revenue from taxation as a major source. On the other hand, enterprises provide various goods and services while seeking profits.

In addition to them, recently nonprofit organizations (NPO) or non-governmental organizations (NGO) have been widely recognized as an important pillar of social activities. This change results from our current understanding that our society requires a lot of social services which citizens should provide on their own initiative. The activities of NPOs or NGOs cover a variety of fields; for example, welfare and medical treatment, social education, urban planning, culture and sports, disaster relief, and environmental preservation. In the field of environmental preservation, there are wide-ranging activities such as nature conservation movements, promotion of recycling, collection of ozone-destroying CFCs, and campaigns against nuclear power stations. Some groups appeal to world opinion and apply pressure to the Government to take necessary measures in order to solve worldwide problems such as global warming. The activities of these NPOs or NGOs deserve a great degree of praise because their persistent efforts contribute to steady social changes.

However, there is a limit to what NPOs and NGOs can do. Revolutionary social changes which are necessary today require radical changes in other pillars of society such as assemblies,

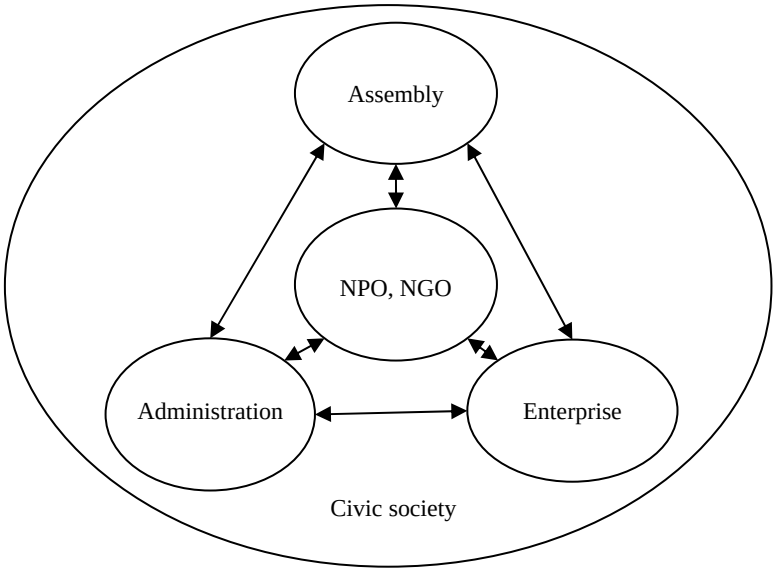


Fig. 5: Main constituents of a democratic society

administrations and enterprises. Furthermore, each individual in a society needs to change drastically.

After all, members of assemblies, administrative organizations, enterprises and non-profit organizations are also citizens. As the electorate, we choose members of assemblies and heads of local governments by vote. As consumers, we buy goods or services provided by enterprises. In the final analysis, in order to realize an ideal society, we must share an image of society, take action, and change the structure of our society.

Change the Structure of Our Society

Relying only on individual initiative, we cannot eliminate environmentally destructive activities and promote environmentally friendly activities. We also must regulate our activities by law as well as encourage changes in our behavior by economic measures. Actually, many such social systems have been already put into operation in Japan as well as other countries. However, most of them carried out in the 20th century were "treatment for symptoms," so they could merely suppress the problems that became prominent. Typical examples of such treatment were the antipollution measures mentioned in Chapter 4.

Treatment for symptoms alone continues to postpone more thorough solutions to problems. Environmental policies in the 21st century must work directly on exploitation as well as production or consumption activities. Examples of such policies are the clarification of legal liability for handling used products, restrictions on the use of toxic chemical substances, and the creation of environmental standards for manufacturing such as energy-saving standards of buildings, cars and appliances. The two most important policies regarding social systems are a "tax and financial reform for environmental preservation" and "land-use planning and control for environmental preservation."

Tax and Financial Reform for Environmental Preservation

This reform, in brief, means making the flow of money through administration ecological. As for revenue, it is essential to raise tax rates of goods and activities that cause environmental destruction and depletion of natural resources. In the case of energy, fossil fuels and nuclear energy need to be taxed more heavily. In fact, European countries such as Sweden, Denmark, the Netherlands, Germany and Italy started imposing new taxes on fossil fuels in order to reduce carbon dioxide emissions.

As for expenditure, it is vital to reduce or end fiscal spending on environmental destructive activities as well as to increase supports for environmentally friendly activities. In the case of energy, priority in budgetary allocation must be considered and shifted from conventional

supports for fossil fuels and nuclear generation to promotion of natural energy and energy conservation. In addition, public works need to be drastically reduced. Environmentally destructive public works such as reclamation works, roads, dams, airports, and bridges must be considered and concentrated on projects that have true value. Especially immense expenditure on road construction, including the revenue source specified for roads in which massive tax revenue is directly connected with the construction of new roads, needs to be thoroughly reformed.

Land-Use Planning and Control for Environmental Preservation

This reform is a turnaround in land use policy from development and construction taking precedence to priority being placed on nature and environmental preservation. When making this turnaround, policymakers must consider all the land which includes coastal areas that can become a target of reclamation. In writing up the details of a land-use plan, administrations of each region should have long-term vision and collaborate with local residents. Important matters to keep in mind are wide-ranging; for example, conservation of irreplaceable natural areas such as virgin forests and tidelands, preservation of water resources, utilization of topographical maps, energy-efficient and safe systems for zoning and transportation, utilization of natural energy, landscaping and cityscaping, suitable urban green space planning for both human and nature.

In order to achieve environmental land-use, the society needs to systematically reconsider legislation relating to land-use. Japanese society has partially begun this reconsideration; for example, the City Planning Law, a core law of that legislation, was revised in 2000. However, the legislation still places priority on development; therefore, bolder reform is needed.

Change Our Awareness

Institutional reform for environmental preservation requires building consensus among people. This consensus can be built on the assumption that people have environmental awareness. In order to change people's awareness, the key is "information."

I have mentioned information; however, this is completely different from the information revolution which accompanied the development of computers. The information revolution accelerates the information transmission speed as well as increases the amount of information; after all, this revolution is as an extension of changes that occurred in the past. Now, what we should truly revolutionize is not the technology of transmitting information, but the "content" of information that should be transmitted.

Concerning environmental problems, what we should provide is the information that

effectively increases environmental awareness (Fig. 6). Such information should be provided through mass media such as books, magazines, newspapers and television as well as new media such as the Internet. In this area, the abilities of information providers, for example journalists and researchers, are put to the test.

In the area of face-to-face communication, “environmental education” is essential. Environmental education needs to be conducted in a variety of places such as schools, workplaces and local communities.

The purpose of environmental education is to increase people’s abilities and motivation to achieve ‘sustainability’ and ‘harmony.’ Environmental education programs should be developed with this purpose in mind, considering age and interest of target learners. Main constituents of programs are transmission of systematic knowledge, observation of the environment or nature familiar to the learners, experience or observation of environmental activities to go ahead. In addition, discussion, debate and role-playing are also important to cultivate people’s abilities to think, create, express themselves, and build a consensus.

Moreover, there are some novel ways to increase people’s motivation; for instance, simulating crises such as disasters caused by global warming that can occur in the future, and experiencing views from astronauts in order to really feel the “finiteness of the earth.” Incidentally, Mr. Toyohiro Akiyama, whom I mentioned at the beginning of Chapter 2, resigned from his television broadcasting company shortly after his space flight and started organic farming.

Chain Reaction of Information Transmission and Establishment of Environmentology

In Chapter 3, I defined humans as “animals that can influence the environment with a sense of purpose.” In this context the term “environment” includes not only natural environment but also social environment. This understanding leads to the following. If the effective transmission of information can change a person’s awareness, the person’s influence on the social environment as well as the natural environment can change. In Fig. 6, the arrow connecting ‘Increase in environmental awareness’ and ‘Information about environment’ shows this relationship.

Increase in a person’s environmental awareness can change the person’s influence on the social environment. This relationship means that the person who has higher environmental awareness can become a new sender of information. Accordingly, once the effective transmission of information starts, chain reaction circulating around ‘increase in environmental awareness’ and ‘information about environment’ can continue endlessly. The range in which this

chain reaction occurs can expand from a small community to a region and a nation, and moreover it reaches international society. In the process of this chain reaction, we can expect an increase in the frequency of environmental action as well as the progress of institutional reform.

At the same time, the above process ought also to produce knowledge and ideas that help to establish environmentology. In Fig. 6, the arrow with a broken line connecting ‘Increase in environmental awareness’ and ‘Environmentology research’ shows this anticipated influence. In other words, in a chain reaction of an increase in environmental awareness followed by the transmission of information, members of our society are rapidly beginning to think all together and act all together.

I will devote my efforts to establishing environmentology as well as expressing the research results as clearly as possible.

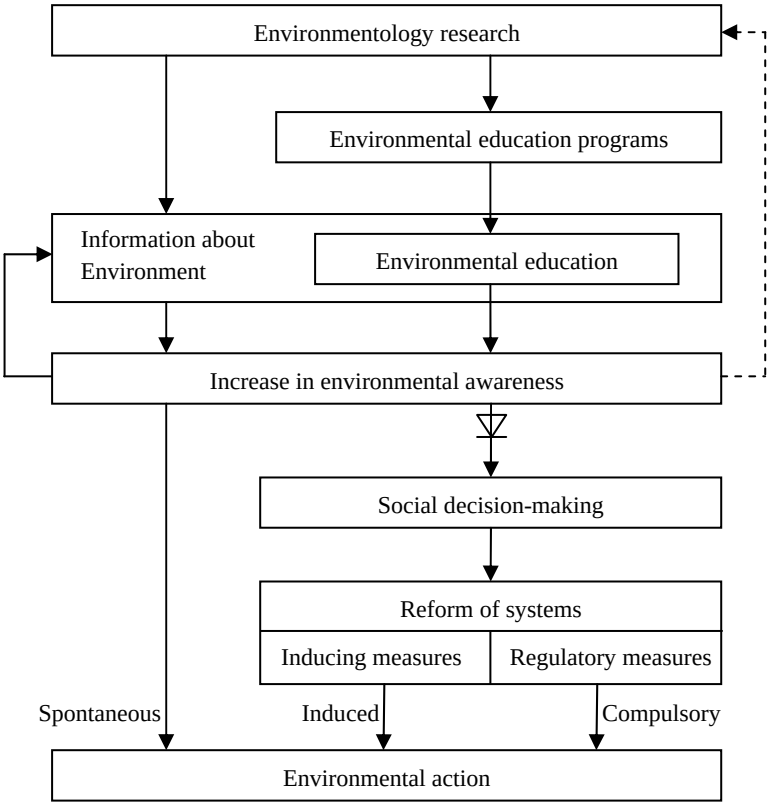


Fig. 6: Promotion of environmental action derived from the increase in environmental awareness followed by information transmission.

(Note) The sign of a semiconductor that is put between ‘Increase in environmental awareness’ and ‘Social decision-making’ means that social decision-making can occur when people’s awareness increases above a certain level.