

Theoretical Possibility of Reconstructing Economics, Making both our Economy and Biosphere Sustainable

我われの経済と生命圏が共に持続可能
となる経済学の再構築の理論的可能性について

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キーワード : ガイア、生命圏、持続可能な成長、勿体無い、地球温暖化

Summary

We must reconstruct the way of thinking of how to research the situation of energy development as the eventuality comes when we have to change our way of manufacturing, delivering merchandise, consuming it, emitting waste, and recycling it. That is a zero emission economy managing to live with the aid of the interest of nature and not with the fund of it. The day when we will have to live according to renewable energy is coming so soon that we must formulate a new way of life styles and the delivering systems and recycling wastes into the renewable energy system from the point of view of recovering Gaia and not damaging her health. It is our urgent task for our descendants. We must move away from industrial militarization, aid newly industrializing countries, and make our vulnerable planet united.

要約

今、我われは過去の大量生産・大量消費社会のつけである地球温暖化の脅威と石油資源の枯渇に脅かされながらも、太陽光、風力、バイオマス、地熱など新しい再生可能なエネルギーの導入が着実に進められている。この間、地球生命圏にとってのアキレス腱であるガイアは傷つき、この状態が放置されると更なるカタストロフィへと進んでいくであろう。危機を回避し我われの子孫に美しい地球を残すために、今新しい経済学構築の必要性が問われている。

Introduction

This article is the result of my lectures in the department of business administration of *Tokaigakuen University* in Japan.⁽¹⁾

During some ten years or so, I have been trying to find the possibility of constructing the inter-correlation between Economics and Life-Sciences. Facing the environmental catastrophe that is the result of human economic activities, it seemed necessary for me to make a new category of activating our task for preserving our biosphere and rescuing our planet.⁽²⁾⁽³⁾⁽⁴⁾ By chance, I tried last autumn to achieve this ambitious vision of restructuring old economics and reconstructing a new one for my students attending my class of environmental business strategy.

Before opening my lecture, I met with my English colleague and asked him “How do you say the Japanese word *Mottainai* in English?” And his answer was, “Don’t throw it away, recycle it.” There is no word that has the same meaning of the Japanese *Mottainai* in English, so I think that Japanese have our own way of expressing the preservation of our environment. And we used to say *Mottainai* for a very long time from the *EDO* feudal period, when this word became a slogan or philosophy that means our attitude of taking care of our environment. As *Mottainai* is correlated to the idea that nature helps us, and we should thank nature for her blessing and live a frugal life accordingly. It is also a doctrine of *Buddhism*. We live depending on the surplus of natural production and reproduction, so we must not use up natural fund itself.

Our grandmothers and grandfathers always taught us in our childhood days that we should not throw anything away and should use it again and again until it can not be used any more. In those days, we could not easily get anything we wanted because we did not have the dynamic domestic economic activity which could enable us to satisfy our basic needs and to buy anything we desired.

***Mottainai* - a prototype of zero emission**

But as everyone knows well, mass production and mass consumption threw our word *Mottainai* away into the mountain of waste. Nowadays we seldom hear people saying *Mottainai*. It became a dead word.

Kenyan Nobel Peace Prize Winner, Wangari Maathai, says in her book⁽⁵⁾ as follows: Sometimes people ask me, “Is there any relation between peace and the environment?” Then I answer, “Many wars could happen as a result of competition for natural

resources as they become increasingly scarce”.

I felt a wonderful feeling because she expressed her deep intimate friendship for the Japanese fade-away life style, and thought that by sharing this word we can give easy access to the road reaching to the green, zero-emission economy. But it should not be an anachronism that means going back to the old good days. We must not make an anachronistic mistake. We should keep it in mind that we cannot change anything by turning the clock backward to the past.

Some thirty years have passed since Japanese were said to have no face enabling to imagine their true identity for foreigners. Japan has made a miracle economic quantum jump during the past fifty years, by the superiority of the excellent skills of manufacturing electrical goods, computers and cars. Japanese car manufactures are still installing car factories all over the world. This is our pride but at the same time our business success will bring a worse environmental situation.

One African woman, Wangari Maathai, taught us to have a wider vision of sustainable development of the economy and business. In this article, I would like to make *Mottainai an internationally known* word like Tsunami.

In the following chapters, I will construct a super version of economics that is different from the old economics tending to destroy environmental unity of the biosphere and to have global warming, the green house effect, and the external chemical conditions that are needed for the survival of life - GAIA. Gaia will be discussed in the latter chapter.

This will be an ambitious attempt of to create a new text for preserving our green planet for our future descendants. Our concept of economic activities includes only our human activities that have prevailed during only two hundred years or so, excluding our friendly biosphere.

It is true that we created a foundation on which scientific economics was formulated by changing the natural agricultural economy into the modern, artificial and market-oriented one. Our way of thinking of how to manage economic and business activities is dependent on this narrow and old vision. Only one exceptional person who considered our economy would have limits for economic development was J.S. Mill who argued in his book⁽⁶⁾ as follows: Our economy will develop to feed increasing population by the innovation of production systems but we will soon face the limit of its development by over-consumption of natural resources needed for our economic activities. So the day

will come, when we will have to stop this economic development, to decrease the surplus population and to endure an awful pain, so we had better have a preparation of it in mind.

His prediction came true and now we must do our homework so that J.S. Mill put on our generations.

Economy originally means lifestyles that manage to maintain the household effectively, so has the common basic rule that covers from cyanobacteria⁽⁷⁾⁽⁸⁾ to human beings in all biosphere's histories. The departure of modern economics is certainly "The Wealth of Nations", by Adam Smith, and although we can learn many things from him, it is only some two hundred years old, and it seems to me to be a human egoistic view of thinking of our economy that only one system can manage our planet.

Absorbing nutrients, making use of photosynthesis, producing energy, making colonies, maintaining species, and developing new ones by evolution from primitive cells to modern mammals are the same principles of our human economy. We also make use of the food chain system. It is absurd to think of only one type of human economic activity that has prevailed on the planet for some 250 years. Our economy is a part of economy that the biosphere has collectively made during the past four billion years. And our economy cannot run well without it. Our economy deeply depends on GAIA. Our economy and business seems to be flourishing on the tuff basis of biosphere and GAIA.

Our planet management

Our students are learning business administration in our university and we have nine courses that students alternately select in their own studies. They are Entrepreneurship & Management, Marketing Management, Finance & Securities, Accounting, Information Management, Welfare Management, Public Management, International Business, and Sports Management⁽⁹⁾. In my view, these nine courses were constructed on the concept that we can manage anything related to our activities from the point of view of business administration. The narrow concept of business administration was enlarged according to our wide and global activities. We can manage human-sphere, socio-sphere and bios-sphere in relation to the principle of biosphere.

The former environment management course was abolished a few years ago because there were a few students who wanted to take it. But the importance of managing the

earth never changes.

If we succeed in getting a new and an enlarged version of economics we can also develop a new business administration using Gaian theory. This is the main theme of this article. Business administration evolved from the main branch of the science of economics. If economics evolves, business administration evolves. We can put spirit in the body of business administration managing the environment.

As I said above, we live depending on the net surplus of natural production and reproduction, so we must not consume the natural fund itself, because if we do so, the pie becomes smaller and smaller, disappearing in the end. I wonder if there also is a break-even point⁽¹⁰⁾ in nature and we can formulate it. It may exist on the border of the interest and the fund of nature.

Nicolaus Copernicus(1473-1543) was the astronomer who provided the first modern formulation of a sun-centered theory of the solar system, in his epochal book, 'On the Revolutions of the Celestial Spheres'.⁽¹¹⁾

Now that we are facing a planet-level environmental avalanche we need a new formula for a life-economy science of the biosphere including mankind. The essence of it will appear if we can endure a painful but hopeful endeavor in studying life sciences. In short, we can make a new formula of the economics of the biosphere if we observe it in a wider scope - the natural economy and green economics.

In orthodox economics we have two divisions of economic history and the history of economics. They ordinarily are the texts that contain descriptions from the industrial revolution to the present day business affairs and ones that describe the human artificial economy, excluding the biosphere's economics. If we had a green economy that we need today, at the beginning of the industrial revolution, the present day landscape of the biosphere would be very different from today's real world. But we cannot go back to the past and rebuild it. At first, we will briefly trace the economic history of the biosphere.

The economic history of the biosphere

13.7 billion years ago, the universe began with a big bang and numerous galaxies were self-organized and 4.7 billion years ago our sun was created and lit our planet by nuclear reaction. Our planet was born gathering the waste of super-over of the sun 4.55 billion years ago, and the economic history of the biosphere began. When the earth

became cool enough to experience chemical reactions, primitive life was born in the primeval sea. The water in those days consisted of very toxic hydrogen sulfide. This original life absorbed nutrients from the hydrogen sulfide oceans. It was very different from today's world because he can never live in the oxygen circumstances.

Later, 3.6 billion years ago, a kind of blue-green algae named cyanobacteria which lived in the shallow under-sea water flourished explosively. Their economy was photosynthesis making energy – carbohydrates – using sunlight, water and carbon dioxide. The environmental pollutant that cyanobacteria produced under the sea was oxygen that is now necessary for most lives on this planet including human. The old types of life could not live under the hydrogen sulfide conditions and the natural economy changed decisively. Next appeared life that can survive in oxygen conditions, and oceans became full of oxygen making iron dioxide with iron-ions in the water.

It is important that the early biosphere first gave birth to Gaia on our planet, making it comfortable for the living creatures and forming homeostasis for the environmental conditions on our planet. Gaia was born. Gaia is, by James Lovelock, the chemical and physical conditions that life made and that make life comfortable to live with stable degrees of hydrogen ion (ph) in the sea, also stable degrees of oxygen in the air (21%), and the fixing of carbon dioxide in the air as well as the sea, and arranging or rearranging of rare substances that are necessary for life.

Wikipedia explains Gaia as follows: The Gaia hypothesis is an ecological theory, proposing that the living things on the planet Earth function like a single organism. An early recognition of some of the core assumptions of the Gaia hypothesis was given in the book *Lives of a Cell* by Lewis Thomas. It was first scientifically formulated in the 1960s by the independent research scientist, James Lovelock, as a consequence of his work for NASA on methods of detecting life on Mars. He wrote an article in the science journal *Nature*, before publishing the concept in the 1979 book *Gaia: A new look at life on Earth*. He named this self-regulating living system after the Greek goddess Gaia, using a suggestion from his friend novelist William Golding. The Gaia Hypothesis has since been supported by a number of scientific experiments and provided a number of useful predictions so is properly referred to as the Gaia Theory.

Therefore we have to formulate a new economic version of Gaian theory that enables human beings to live under the rule of the Gaian self-regulating life system because we are a part of Gaia. The name of this new version of economics may be Gaian Economics

that include Gaian Business Management. Gaia manages so well the entire biosphere, that it has the management faculty of the biosphere. Human being must learn the skills from the Gaian world.

The natural economy

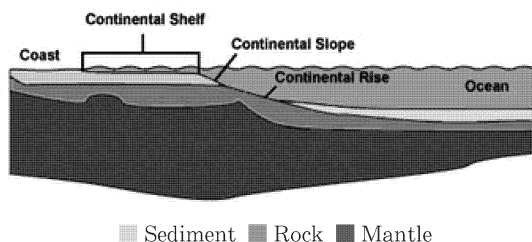
Recently, I fortunately found the late Carl Sagan's book 'BILLIONS AND BILLIONS' in a bookstore and read it in time for writing this article. He wrote as follows: The earth is an exceptional planet. It is the only planet where life lives in the solar system as far as we know. We human beings are one of millions of species that habits the world where life is born and flowers. But many of the old species that flourished yesterday have already disappeared. The dinosaur died after they flourished for 180 million years. Though it is only one million years since we were born on the earth, we may become the first species that will destroy itself by our own methods. We have a responsibility to fight for the sake of life on earth, I believe, for species that existed previously, all species that we owe our existence to, and all species that will be born in the future. Human beings produced all the problems and therefore they can solve all of them. This task is more important than any other social habit, administrative organization, economic hypothesis, and religious discipline.⁽¹²⁾

One feasible approach that Gaian economics must do will be inspecting Gaia's damaged Achilles' tendon, taking care of her, and finding another way of managing our economy. As I shall show later repeatedly, the Gaian self-regulating system depends on the area of continental shelves, tropical forests, mangroves, natural forests, tidal flats, wetlands, lakes and ponds. These places are essential for the health of Gaia and are important for human business activities too.

For instance, continental shelf is as follows: The continental shelf is the extended perimeter of each continent, which is covered during interglacial periods such as the current epoch by relatively shallow seas and gulfs. Combined with the sunlight available in shallow waters, the continental shelves teem with life compared to the biotic desert of the oceans' abyssal plain. The relatively accessible continental shelf is by far the best understood part of the ocean floor. Most commercial exploitation from the sea, such as oil and gas extraction, takes place on the continental shelf. Sovereign rights over their continental shelves were claimed by the marine nations that signed the Convention on the Continental Shelf drawn up by the UN's International Law Commission in 1958

partly superseded by the 1982 United Nations Convention on the Law of the Sea.(13)

We have tried to build environmental policies until now known as a direct regulation system by law against many kinds of environmental pollution, and indirect incentives such as the recycling system, zero-emission, Life-Cycle-Assessment (LCA), ISO14000, ISO19000 series, deposit system, car sharing, eco-money, environment marketing, and so on.



It is true that we have been exploiting so many resources such as oil, manganese, and natural gas, from the continental underground, that I wonder if we have moved out of the ring of the biosphere or not. The answer may be yes. As we breathe the air, drink water, eat fish, beef, vegetables, fruits, corn, and use wood for building houses, heating, making furniture, we may still be part of the biosphere.

But we have so large a scale of manufacturing of cars, electrical goods, computers and other products that we may come outside the natural food chain. We maintain our economy by an artificial food chain that is equivalent to a pyramid-featured production system.

J. Lovelock says that the man-made three Cs - the chainsaw, car and cattle destroyed the environment. So far as we know about the condition of nature, we cannot exactly determine if we are still the members of the biosphere or not, it is sure that we are proceeding to the epoch that will need a Noah's Ark some day. But we must not let our descendants make a second Noah's Ark. According to the Bible, Noah's Ark was a vessel built at God's command to save Noah, his family, and a core stock of the world's animals from the Great Flood.⁽¹⁴⁾

Our natural economic history follows as:

One billion years ago our primitive life evolved into Mesozoa which still lives in the body of Octopus or Squid and after the Cambrian big explosion (545-490 million years ago), Pikaia appeared on the stage of history and swam in the waters. He had spine-like born which later evolved into a mammal's spine. He seemed like the first fish. Later fish

were born in the seas and went out to the rivers running away from their enemies or catching foods. And 400 million years ago, fish evolved into a kind of primitive Amphibian, Eusthenopteron, and Amphibian animals flourished in the rivers.

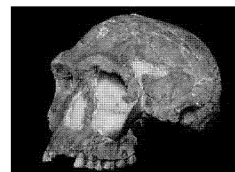
A fossil of a 360 million year old Amphibian, Ichthyostega, was found in Greenland. It had strong hands and feet, but was thought to be unable to walk on land because of its heavy weight.



eusthenopteron



Ichthyostega



Homo habilis

Plants had already developed on the land and flourished on the ground. Amphibian animals evolved, reptiles and later mammals were born by Darwinian natural selection. 110 million years ago, Magnoliophyta that flowered and made seeds and fruits appeared on the land and flourished in the midst of the dominant Gymnospermae that produced its descendants by spore.

Our ancestor mammals made their economy by coexisting with Magnoliophyta plants. Edmontosaurus which were 9-13 meters tall flourished 71-65 million years ago, and ate a great mass of conifer every day and went northward to find new conifer. When a great asteroid burst on our planet and the black cloud above the earth shut sunlight out, Edmontosaurus became extinct. If this theory of their extinction is correct, living creatures that destroy the environment and become outside the biological ring will themselves be destroyed entirely. One life scientist argued that the average life span of a species is 1-11 million years and in the case of mammals is 2 million years.

Our ancestor mammals survived under the cold snow during the glacial days and evolved into the first monkeys, next chimpanzees walking around on the savanna in central Africa some five million years ago. two million years ago, Homo habilis (photo), whose brain was 750ml big, was living on the Kenyan savanna and evolved into Homo Sapience.

Twenty thousand years ago, our brain became nine hundred grams in weight and animals were caught systematically using spears. Twelve thousand years ago, our ancestors learned to cultivate the soil and put seed down in it - agriculture. Pandora's box was opened at last. We first had the ability to remake nature and use it for our

survival. Two hundred and fifty years ago the industrial revolution exploded in England and its impact affected the whole planet. At last we built up an artificial cluster of buildings of sophisticated technologies.

Gaian economics - application of Gaian theory to economics

It is not true that we have not made an effort to develop a new economic system to escape from the catastrophe of environmental disaster. We have now a volume of books that refer to economic approaches to prevent economic activity from emitting pollutants or destroying the environment. It is the environmental economics known widely as green economics.

According to Wikipedia's definition, environmental economics is a sub-level of economics concerned with environmental issues. In using standard methods of neo-classical economics, it is distinguished from green economics or ecological economics which include the non-standard approaches to environmental problems, environmental science / environmental studies, or ecology.

A related field (or possibly alternative approach to the same field) is ecological economics, which takes as its premise that economics is itself a strict sub-level of ecology.

My methodology looks like ecological economics but is different from it because our environmental economics is a part of Gaian theory, not a part of ecology in general. The core concept of environmental economics is the social cost of economic activity. American economist K.W. Kapp first introduced this idea of social cost.⁽¹⁵⁾

Wikipedia's sophisticated definition of social cost is as follows:

Social cost, in economics, is the total of all the costs associated with an economic activity. It includes both costs borne by the economic agent and also all costs borne by society at large. It includes the costs reflected in the organization's production function (called private costs) and the costs external to the firm's private costs (called negative externalities or external costs). If social costs are greater than private costs, then a negative externality is present. Environmental pollution is an example of a social cost that is seldom borne completely by the polluter thereby creating a negative externality. If private costs are greater than social costs, then a positive externality exists. In either case, economists refer to this as market failure because resources will be allocated inefficiently.

Negative externalities (external costs) lead to an over-production of those goods that have a high social cost. For example, the logging of trees for timber may result in society losing a recreation area, shade, beauty, and air quality, but this loss is usually not quantified and included in the price of the timber that is made from the trees.

As already mentioned above, we have an important cluster of environmental policies and laws in all of the nations and NGOs are working in various ways and methods of activities. Our aim of Gaian economics is to put a crucial 'value added' to this theoretical basis including environmental economics and biological economics.⁽¹⁶⁾

Economy of helping Gaia to recover

I want to borrow Carl Sagan's words as follows: We must develop a science to raise the level of conditions of the earth and to research and understand the situation of the world. It is time to think and act from the point of view of the earth, whole lives and the age of future children, in addition to the viewpoint of our nations and our age - to say nothing of certain industrial benefits.⁽¹⁷⁾

If we systematically inspect the sun, the air, clouds, surfaces, and oceans from outer space, airplanes, vessels, and grounds, we can diminish unclear part of them, catch a ring of feedback, watch patterns and influences of the regional pollution, trace the feature of forest diminishment and enlargement of deserts, monitor the change of heights of polar ice glaciers and sea level, and research chemical reactions that happen in the ozone layer.⁽¹⁸⁾

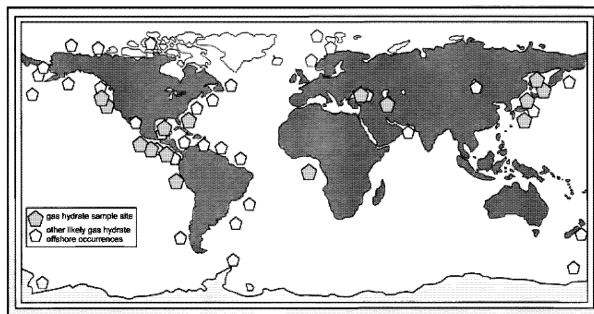
Then how much time is available for us to cope with this environmental crisis? Is it thirty years, forty years, or more? We will consume oil reserves under the continental shelf in forty-two years. On the contrary vast demands for oil come from newly industrializing countries such as China, India, Korea, and Vietnam. In turn African countries and Venezuela want to sell their oil to industrialize their countries. Oil companies are digging new oil wells but they do not last long more than forty years limit. Side by side with this energy crisis, new kinds of renewable energy - wind turbine, solar panel, geothermal plant, ethanol fuel⁽¹⁹⁾ have been marketed recently.

Even small Japanese factories downtown can make a satellite for watching climate conditions and we have the fastest computer⁽²⁰⁾ in the world to evaluate the effects of global warming.

On the contrary, methane clathrate or methane hydrate is said to be a post-petroleum

energy source, now that oil will not last so long. Methane hydrate is as follows:

Methane clathrate, also called methane hydrate or methane ice, is a form of water ice that contains a large amount of methane within its crystal structure (a clathrate hydrate). Extremely large deposits of methane clathrate have been found under sediments on the ocean floors of the Earth.



Worldwide distribution of confirmed or inferred offshore gas hydrate-bearing sediments, 1996.
Source: USGS, http://en.wikipedia.org/wiki/Methane_hydrate

Methane clathrates are common constituents of the shallow marine geosphere, and they occur both in deep sedimentary structures, and as outcrops on the ocean floor, or crystallization, on contact of the rising gas stream with cold sea water. Methane is a powerful greenhouse gas which, despite its atmospheric lifetime of around twelve years, none the less has a great global warming potential. The sudden release of large amounts of natural gas from methane clathrate deposits has been hypothesized as a cause of past and possibly future climate changes.⁽²¹⁾

We must reconstruct the way of thinking of how to research the situation of energy development, when we have to change our way of manufacturing, delivering merchandise, consuming it, emitting waste, and recycling it. That is a zero emission economy, managing to live with the aid of the interest of nature not the fund itself. The day when we live depending on the renewable energy is coming so soon that we must formulate a new way of living using delivery systems and recycling waste into a renewable energy system from the point of view of recovering Gaia and not damaging her health.

Continental shelves are the place of bio-diversity and life's evolution tends to diversity and complexity, making sure the Gaia self-regulating system that we must not touch

such a place. Or if we have to exploit such a place from economical necessity, we should prudently do so. So re-establishing Gaia's health is our own urgent task for our descendants. Biosphere embraces our economy and our economy is a part of it. We must move away from industrial militarization, help newly-industrializing countries stand on their own feet, and make our vulnerable planet as one.

References

- (1) This article was written by rearranging my lecture note but was largely reconsidered and revised upon it by referring academic articles and books. It can be downloaded from my web cite.
(<http://www2s.biglobe.ne.jp/~segahisa/>).
- (2) Hisashi Segawa, A research on the environmental relationship between oceans, rivers and forests -- a preparatory sustainable socio - life science. 2004, Bulletin of Tokai Gakuen University. Vol.9 (No.1)
- (3) Hisashi Segawa, An Essay about the Model of socio-Life Science. 1999.03
The Journal of Law and Politics, Shizuoka University. Vol.3 (3,4)
- (4) Hisashi Segawa, 2006, Complexity and the regional commonwealth. Shizuoka Local Autonomy Bulletin No.35, Shizuoka Local Autonomy Research Center
- (5) Wangari Maathai, 2004. The Green Belt Movement. Lantern Books - Sharing the Approach & the Experience . I could not use this English book in time for writing this article , so I cited her words from the Japanese version.
- (6) John Stuart Mill, Principles of Political Economy.
I also could not use the English version, so the quotation is from the Japanese translation.
- (7) Cyanobacteria have a property that produces oxygen by photosynthesis. There are some types of bacteria, swimming in the water in one cell, making colony with a small number of cells and forming string-like cells.
Explanation is cited from the Japanese Internet Wikipedia, the free encyclopedia.
http://en.wikipedia.org/wiki/Main_Page
- (8) Cyanobacteria are often referred to as blue-green algae. The description is primarily used to reflect their appearance and ecological role rather than their evolutionary lineage. Fossil traces of cyanobacteria have been found from around 3.8 billion years ago. As soon as these blue-green bacteria evolved, they became the dominant metabolism for producing fixed carbon in the form of sugars from carbon dioxide. Cyanobacteria are now one of the largest and most important groups of bacteria on earth.
Explanation is cited from English internet Wikipedia.
http://en.wikipedia.org/wiki/Main_Page

- (9) <http://www.tokaigakuen-u.ac.jp/eng/index.html>
- (10) The break even point in economics is the point at which cost or expense and income are equal - there is no net loss or gain, one has “broken even”. The point at which a firm or other economic entity breaks even is equal to its fixed costs divided by its contribution to profit per unit of output, which can be shown by the following formula:
 Breakeven Point = Fixed Cost over Contribution per Unit Output
 Explanation is also cited from the English internet Wikipedia
- (11) Copernicus was one of the great polymaths of the Renaissance. Amid his extensive responsibilities, Copernicus treated astronomy as an avocation. That notwithstanding, his formulation of how the sun rather than the earth is at the center of the solar system is considered one of the most important landmarks in the history of science. It forms the starting point of modern astronomy and, in turn, of modern science.
 Explanation is also cited from the English Internet Wikipedia.
- (12) Carl Sagan(1934-1996), Billions and Billions - Thoughts on Life and Death at the Brink of the Millennium, 1997, The Estate of Carl Sagan
 I must apologize that I could not read his English version and translated Japanese into English. So the pages that I referred to are the Japanese version. P.101
- (13) Explanation is also cited from the English Internet Wikipedia.
- (14) The story of Noah’s Ark begins with God observing man’s evil behaviour and deciding to flood the earth and destroy all life. However, God found one good man, Noah, “a righteous man, blameless among the people of his time”, and decided that he would carry forth the lineage of man. God told Noah to make an ark, and to bring with him his wife, and his sons Shem, Ham, and Japheth, and their wives. Additionally, he was told to bring examples of all animals and birds, male and female. In order to provide sustenance, he was told to bring and store food.
 More: http://en.wikipedia.org/wiki/Noah%27s_ark
- (15) K. W. Kapp, “The Social Costs of Private Enterprise”, 1948
- (16) Ecological economics is a branch of economics that addresses the interdependence and co-evolution between human economies and natural ecosystems. It has similarities to green economics and human development theory. These schools also embrace integration among diverse intellectual thoughts, and deem neoclassical economics as myopic and closed-minded; ecological economics seeks greater trans-disciplinary connections to solve complex issues facing humanity.
 More: http://en.wikipedia.org/wiki/Ecological_Economics
- (17) Carl Sagan, op cit,
- (18) Carl Sagan, op cit,
- (19) Ethanol fuel is an alternative to gasoline. It can be combined with gasoline in any

concentration up to pure ethanol (E100). Anhydrous ethanol, that is, ethanol without water, can be blended with gasoline in varying quantities to reduce the consumption of petroleum fuels, as well as to reduce air pollution. In the US, tolerance of ethanol depends on the individual vehicle.

More: http://en.wikipedia.org/wiki/Ethanol_fuel

- (20) The Earth Simulator(ES) was the fastest supercomputer in the world from 2002 to 2004. The system was developed for NASDA, JAERI, and JAMSTEC in 1997 for running global climate models to evaluate the effects of global warming. It has been able to run holistic simulations of global climate in both the atmosphere and the oceans down to a resolution of 10 km. Located at the Earth Simulator Center in Kanazawa-ku (ward), Yokohama-shi, Japan, the computer is capable of 35.86 trillion (35,860,000,000,000) floating-point calculations per second, or 35.86 TFLOPS.

More: http://en.wikipedia.org/wiki/Earth_simulator

- (21) More: http://en.wikipedia.org/wiki/Clathrate_hydrate