〔Introductory paper〕

The Basic Construction of Vertebrates, Structural Defects in the Human Body and a New Concept of the Immune System

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Abstract

Establishment of basic construction of the vertebrates was carried out during neoteny (larval form evolution) of the hemicordata, which integrated the respiration, nutrients, and excretion system into only one tube of the gut. Through evolution of the vertebrate, mammals evolved after four kinds of vertebrate-revolution. These evolutional phenomena can be seen as revolutionary transformation of morphology in biomechanics responses to environmental changes. Through these evolutional transitions, various kinds of concerns develop between morphology and the function of organs in the human body from the standpoint of basement construction of the vertebrates. Trilateral Research combining phylogeny-ontogeny, biomechanics, and molecular genetics is proposed in this paper. Through this new research method immune system was studied and a new concept for immunology as cytological digestion system was also proposed.

Key Words: Neoteny, Morphology, Function, Evolution, Biomechanics, Archetype Immune System, Vertebrate, Phylogenesis-ontogenesis,

1. Basic Construction of Vertebrates

Observation of relations between the construction, functions and morphology of the human body from an engineering viewpoint suggests a number of unexpected biomechanical structural defects.

In this paper the process of vertebrate evolution is discussed from the combined viewpoint of phylogenesis-ontogenesis and biomechanics in order to see the human body from an engineering standpoint and the author also reviews the structural defects of the human body according to *The General Morphology of Organisms* written by S. Miki [1,2]. After that trilateral Research combining phylogeny-ontogeny, biomechanics, and molecular genetics is proposed in this paper. Through this new research method immune system was studied and a new concept for immunology as cytological digestion system was also proposed.

Living organisms, including multicellular creatures and higher animals, have enormously diversified shapes. Are there any basic designs for the bodies of higher organisms? What is the initiating factor in evolution? The questions that occurred first in the sciences of life were those related to morphology and function. In modern science, the first person who noticed the presence of archetypes as the basis for higher organisms, including animals and plants, was the poet Goethe, who established the new scientific area of "Morphologie". He defined morphology as a science whose ultimate objective is to clarify the mechanisms of morphological transformation, and he also studied vertebrate archetypes up to the human being. Goethe stated that even the body of a human being "has reached today's shape through transformations every moment after the creation of life, starting from the prototype in the archeozoic age". Goethe's lifelong theme was the importance of "the principles of modification of shapes", which was later called phylogeny by Haeckel. In those days, Lamarck and Cuvier in France greatly contributed, as did Goethe, to

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the establishment of a new scientific area, which is called "life science" today. Lamarck made Biologie independent from natural history (1802: Lamarck & Treviranus) through studies of invertebrates and proposed the evolutionary concept that the archetypes of living beings are changed by external as well as internal factors according to the Use and Disuse Theory. This was a more definitely scientific realization of Goethe's Morphologie of the modification of archetypes under biomechanical influences. On the other hand, Cuvier established the basics of comparative vertebrate anatomy at the age of 27, and proposed the principle of the dependence and correlation of organs (1795); however, under the patronage of Napoleon, he advocated the theory of the unchangeability of life and made efforts to abolish Lamarck's concept of evolution.

Various living beings exist on the earth, but there are comparatively few basic macromolecular substances which are common to all living beings; that is, nucleic acids constituting the gene and amino acids constituting proteins. There are various substances for skeletal systems related to morphology and, since the substances are not the same, the basic morphology and the modifications appropriate to each kind seem to be different. The skeletal systems of the organisms on earth can be divided approximately into five kinds: the cellulose system for plants, silicate system for diatoms, calcium carbonate system for shellfish and coral, chitin system for insects, prawns and spiders, and the collagen apatite phosphate system for vertebrates. To those listed above only the last two skeletal systems have effective response systems to biomechanical stimulation. Because of this, only the invertebrates having chitin systems and vertebrates display a morphology associated with functions.

Coelenterate and Pterobranchia, having no skeleton, are able to change their morphology relatively freely in conformity with their functions. Invertebrates that developed a chitin-based skeleton evolved into organisms such as crabs and insects with social organizations, but because of their external skeleton, their remodeling system of ecdysis was limited, and therefore they failed to achieve larger size. The collagen apatite-based internal skeleton of vertebrates was able to change its shape by remodeling in response to external as well as internal forces. Also, they were able to grow to huge sizes and to adapt and radiate, forming considerably diversified species.

In the period when the earth was covered with a luxuriant growth of trees, huge dinosaurs appeared, but groups of animals permitted to emerge only at night in the free space left around the dinosaurs were secretly developing a higher-efficiency faster-acting metabolic system. These animals developed into mammals, lived throughout the severer environment of the Ice Age, and survived to today's Age of Mammals.

The definition of a vertebrate is "a chordate having a bony backbone, with the various degrees of ossification". Therefore, it can be said that the bone structure is the defining characteristic of the vertebrates. For this reason, the mechanisms of evolution in vertebrates can be clarified by investigation of bone characteristics. Bone is a connective tissue calcified by hydroxyapatite, so that collagen seems to be as important a substance as apatite for characterizing the vertebrates. The archetype of the bone structure is derived from a carapace called aspidin, which is a composite of dentine and bones forming the armor of the Pisces in the Archeozoic era. This aspidin was an excretion system for calcium which existed in high concentrations in the Archeozoic sea. The aspidin may also have had a storage function for phosphates, which were in short supply in the seas [4].

The starting point of the evolution of the vertebrates is the incorporation of respiratory apparatus into the gill cleft from cutaneous respiration system of Pterobranchia, and the acquisition of an apatite bone structure. Therefore, the ultimate archetype of our human ancestors can be seen in the larva of the Ascidia according to S. Miki [3] (Fig. 1).

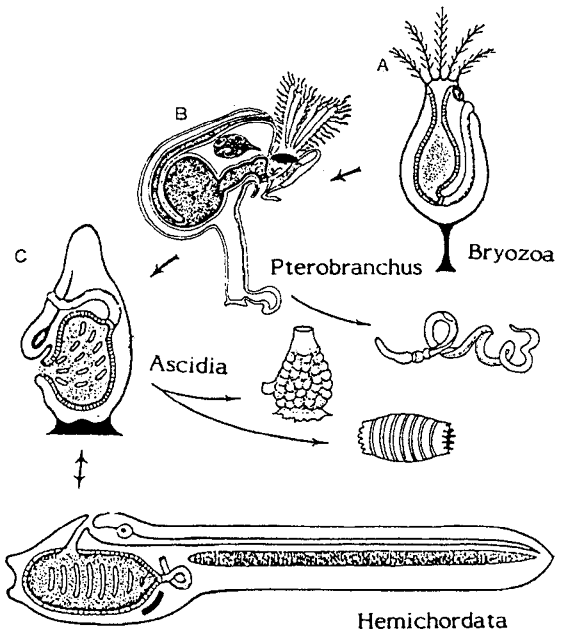

Fig. 1 Metemorphosis of Branchia

Since animals cannot synthesize energy sources independently from the immediate environment the fundamental characteristics of animals are related to moving around in search of food. In morphological evolution, empirical laws exist which state that the form changes according to the method of using the body just as in the Use and Disuse Theory. That is to say, the characteristics of behavior decide form and structure. Repetitive behavior can be seen as a function in many cases, and therefore form changes in accordance with function [5]. Because of this, the evolution of form occurs depending changes in the environment. Environmental change promotes change in biomechanics.

The primitive vertebrate form began with the acquisition of a system using a gut for an absorbent and excretion system, respiration, nutrition, urination and generation. Maintenance of this system required the notochord of hard tissue. Use of bone made of collagen apatite compounds for this hard tissue made adaptation and radiation possible for the vertebrates. Particularly, the fact that the hydroxyapatite is based on the Calcium ion which is indispensable for life activities and phosphate which is indispensable for cytological respiration as well as energy and nucleic acid metabolism - this fact is considered to have far-reaching significance.

Living phenomena are systems struggling for self-continuation by utilizing energy from the incorporation and decomposition of environmental factors, so that the life can be said to essentially depend on the environment. Therefore, all vital reactions can be considered as biomechanical responses to environmental factors, including gravity, chemical and photoelectric reactions.

2. The Prototype of the Immune System and its Biomechanical Modifications-A New Concept for the Immune System Vertebrate evolution begins with the integration of the absorption and excretion systems for nutrients, including respiratory oxygen and bicarbonate, into the single tube of the gut.

The completion of the gut nutrition system showed an essential harmony between the forms and functions of the digestion, absorption, secretion, and uro-genital systems. In previous organisms and also in invertebrates, respiration was carried out through cutaneous organisms.

Branchial respiration was accompanied by the establishment of the immune system. This can be considered to be an induction of functional cells which correspond to useful or harmful substances as they are incorporated as digestion of feed from the gut. Therefore, hemopoiesis can be seen as cytological digestion in mesoderm. There are the leukocyte for defense and erythrocytes for transport of nutrients or metabolites as cytological digestion and it can be seen that the immune system is closely related to the hematopoietic system. From this viewpoint, it can be said that the gut system is the same as the immune and nutritional systems, so that all the associated organs are also related to the immune organs (Fig. 2). These are the gastrointestine, liver, spleen, pancreas, thyroid gland, accessory thyroid, lungs, hypophysis and Waldeyer's ring (Fig. 2).

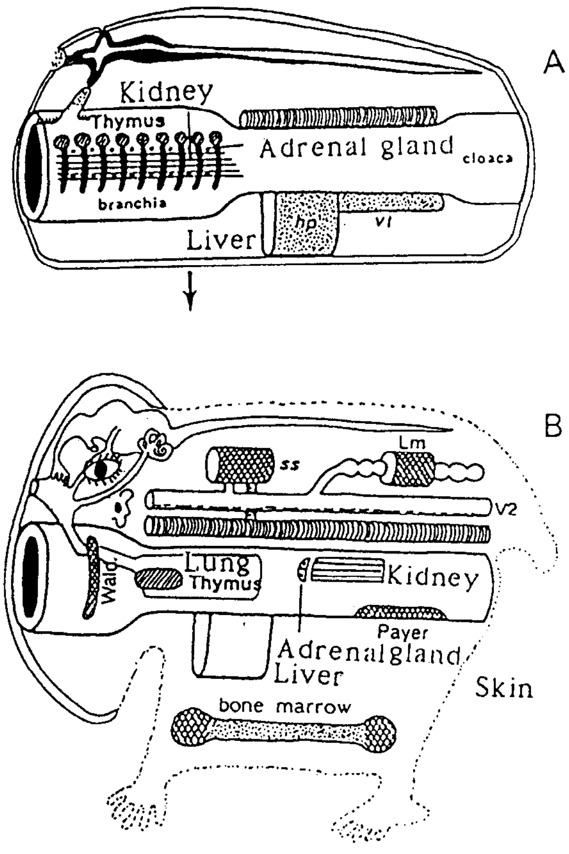

Fig. 2

On the other hand, the urinary system (kidney) is in charge of catabolism systems and it is a system of the mesodermal epithelium which extracts waste products from the blood and excretes them. Also, the genital system is for excreting genes for the next generation as the most essential for life, therefore, the genital system in its origin is closely related to the hematopoiesis of the mesoderm (Fig. 2).

Because these are both mesodermal excretion systems, the urinary and genital functions are carried out by the same excretory organs in vertebrates. This was due to the program created at the Ascidia stage as the starting point for vertebrates. From the above, the genital a nd endocrine systems are understood as all cl osely related to the immune system. In today's medicine, it is often stressed that the immune system has an inseparable relationship with the central nervous and endocrine systems 3). Therefore, this is a new concept of the immune system as cytological digestion including the intestinal, the genital, the endocrine, the central nervous, and the hemopoietic systems.

It is necessary to consider for a moment the myelopoiesis and immune systems of mammals. Myelopoiesis does not exist in the Ascidia program. Why did the hematopoietic and immune systems develop in the bone marrow cavity, which is unrelated to the intestinal nutrition system? In the beginning, the Pisces in the Archeozoic era had no osseous endoskeleton. All endoskeletons were made of cartilage; although they had a bone structure, it formed itself as an armor of aspidin, a complex of dentin and bone.

During the period of drastic changes in the earth's environment in the Devonian era, many of the Pisces had difficulty living in water and were compelled to go ashore. This is the landing drama, sometimes called the second vertebrate revolution. Many seas had become shallow over a hundred million years, with repeated floods and droughts. The approximate process of this phylogenesis was recorded as life memory in the gene and is repeated in the process of ontogenesis (Recapitulation by Haeckel). In the case of the human being, an image of this history of a hundred million years ago symbolically appears in the embryo within the womb during three days, 32 to 35 days after embryogeny[3].

It is necessary to remember here Haeckel's famous biogenetic law (Recapitulation Theory): "Ontogenese recapituliert Phylogenese (1866)". The term used by Haeckel for "repeating" was Recapitulation, which literally means repetition of the top region. However, this theory was unable to explain neoteny when it was discovered, and Recapitulation Theory has come to be neglected and disregarded in the present century. About 100 years after Haeckel, the late professor Sigeo Miki compared ontogenesis with phylogenesis in detail from viewpoint of vascular construction for each organ in the entire body in relation to the morphological changes in evolution. He verified that the process of phylogenesis is symbolically reproduced as genetic phenomena in ontogenesis even to the vascular system in an extremely short time. Today, even neoteny can be easily explained by heterochrony in molecular genetics[6].

What were the phylogenetic consequences of the landing drama seen from a biomechanic point of view ? The heavy body weight of the living being wearing armor was canceled by buoyancy in water but, in the landing revolution increased effective weight influenced the cartilage of the endoskeleton, so that osseous tissue was induced from mesenchymal cells which had differentiated into cartilage.

The bone tissue derived from mesenchymal cells covering the body surfaces as the armor of aspidin can be seen as having been induced by mechanical stimulation in water; but on the ground, where mechanical stimulation acts on the endoskeleton of the cartilage, the mesenchymal cells in these parts are differentiated into bone. Osseous tissue has the property of forming osteons following the repeated principal stress trajectories, so that bone marrow cavity is formed.

Hematopoietic nests emigrated into this bone marrow cavity from the liver and spleen (Fig. 2). Actually, as with bone tissue, hematopoietic nests were induced from mesenchymal cells in the medullary cavity, because the medullary cavity (a chamber in the collagen apatite complex) effectively provided more adequate conditions for hemopoiesis than the spleen (collagen chamber). From this, it can be recognized that one of the factor for genetic expression of mesenchymal cells is considered biomechanics.

In this stage, the initial and basic design of Ascidia was profoundly and inevitably modified by biomechanical influences derived from environmental changes. This series of biomechanical responses has been incorporated into genetic phenomena. Here, we become aware of the important role of skeletons composed of collagen and apatite in the evolution of the vertebrates.

3. The Basic Design of Respiratory System and Structural Defects of the Human Body

A serious change, which is even more important than the emigration of the hematopoietic nest, occurred during the second vertebrate revolution; this is the conversion from branchial to pulmonary respiration (Fig. 2). It is necessary here to recall the cartilagenous fishes represented by sharks which succeeded the system of the Pisces in the Archeozoic era.

Bony fish, as the name suggests , have an endoskeleton made of bones as well as myelopoiesis. The spleen is independent, and the metabolism of the kidney is different from that of cartilaginous fish. Moreover, the lung is degenerated and converted into the float as part of the intestine.

As can be seen from this, the bony fishes once experienced terrestrialization in the Devonian period with air respiration on land and then returned to the water [1,2]. Therefore, they became considerably higher vertebrates which had experienced gravity.

Vertebrates have gut respiration as one of their characteristics and the lung derives from the mucous membrane of the gut. Therefore, the lung is a great immune organ, but this is hardly recognized today in medicine.

Respiration is the work of the visceral system, so it must be carried out rhythmically for an organism by smooth visceral muscles as in branchial respiration. The heart is assumed to be a vessel developed according to branchial respiration, so that the most basic and primitive visceral motion in the creature in the Archeozoic era is considered to be respiration.

The terrestrialization of the vertebrates induced the vicarious respiratory system of gut membrane instead of branchia as a temporary expedient. The branchia was effective in water but did not function in the air, so that landed animals performed respiration by the pharyngeal mucous membrane, and absorbed oxygen through the mucous membrane in the intestine of the pharyngeal pouch. As a result, a part of the intestine was developed into a bag shape and then developed into lungs. In this process, the smooth muscles of the branchial gut were left in the branchial arches.

Originally, the mucous membrane of the intestine was an organ capable of absorbing both gas and liquid. It is well known that the loach has intestinal respiration. As carried out by the first Ascidia, which incorporated respiration into the gut from a cutaneous organ, the pharyngeal pouch was taken into the thorax cavity in the landing drama. Actually, it was necessary for the pharyngeal pouch to be placed in the mechanically stable thorax cavity. Through evolution, the pharyngeal portion having branchial arches was constricted and the neck was formed, so that the skull and face became independent from the trunk.

The portion corresponding to the face of a human being was the mouth having a gill cleft in the first Ascidia. And it evolved and differentiated into four parts : head, neck, thorax, and abdomen (Fig. 2). From this, it can be said that the facial skull is the sole portion where the viscero and somato systems are combined together in one unit. Therefore, the face is derived from the major part of the archetypal life with the mouth at the center, and this seems to have evolved into the organ representing life, i.e., the viscero cranium.

In evolutionary changes the respiratory visceral muscles of the branchial arches were left in the head and neck region. What happened to these muscles? They changed into various organs of striated muscles controlling facial expression, auricular apparatus relating to ossicles, articulation, mastication, deglutition and swallowing, which are well developed in mammals. Now, the respiration of terrestrial animals is carried out by striated muscles. Therefore, this respiration system deviates from the original program of the primitive archetype, and this is the greatest defect in higher animals. The muscles of the somato motor are the locomotive system of the brain, so they are not suitable to carry out autonomic visceral movement throughout a lifetime. In somatic muscle movement or during the brain work, respiratory striated muscle is often suppressed. Even during sleep, the striated muscle is often suppressed. Because of this, the respiratory system must be regarded as the most serious structural defect in the human body.

Already more than three hundred million years have elapsed since the terrestrialization of animals occurred, but no smooth muscle for respiration has been acquired. Evolution has a single direction along the time axis and it is merely an accumulation of biomechanical responses to all physico-chemical influences, including environmental changes. Therefore, if the smooth muscle of the branchial arches loses autonomic movement, it may become a striated muscle, but smooth muscle will never be derived from striated muscle for respiration even several hundred million years from now. Nor is there any possibility of the occurrence of smooth muscle by mutation. This is due to the mode of vertebrate evolution, namely, the mode of inheritance.

In this respect, the genetic phenomena of vertebrates become a serious issue. In the vertebrates, as explained above, the morphology of organisms has smoothly evolved in association with functions according to mechanical responses. Abrupt changes in morphology/function such as in mutation are, on this view, regarded as anomalous or destructive. Mutation is in the vertebrates always a deviation from the normal state and is related to a deterioration in morphology and function. Progress into higher form, showing harmony between morphology and functions, is not realized by mutation; it seems to occur through an accumulation of mechanical responses, i.e., through the inheritance of acquired characteristics according to the Use and Disuse Theory [4,6].

Several thousands of continuous modifications in developmental processes including bone marrow hemopoiesis caused by mere mechanical responses and the great change in the respiratory system, are all incorporated into a series of genetic phenomena in phylogenesis and ontogenesis. However, the conversion of striated muscle for respiration into smooth muscle has not occurred in three hundred million years. What does this fact mean? Biomechanically, when function of a sort is provided by striated muscle no other structural development will occur as long as rhythmic stimuli of the nervous system is maintained. The principal driving force of evolution is biomechanics, and transitions of morphology may merely be responses to changes in functions, just as Lamarck proposed in his Use and Disuse theory [4].

For example, let us look at the airway system of the human being. Generally, the nasal cavity is continued to the trachea at the pharynx in mammals, so that an airway for respiration is always guaranteed. This continuity is maintained in a suckling human child just as in a monkey. However, the continuity is lost during the process of acquiring language and the food pathway and respiration airway come to an intersection in the throat. Thus, this construction in the throat is a human-specific structural defect that has been caused biomechanically by the human-specific behavioral habit of vocalization and articulation. Therefore, the habit of mouth breathing is peculiar to humans. Needless to say, these biomechanical responses are incorporated into genetic phenomena [6,7,9].

When a certain animal no longer uses its eyes or teeth under certain circumstances, the functions of those organs are lost, or even the organs themselves can be lost, although the genes are retained and inherited. This phenomenon can be called "lost character", using a value-oriented terminology. The lost character will be inherited. As the main influence of biomechanism can be considered to be the realization of morphology and function through the gene, this phenomenon can be assumed to be the disuse of gene expression by abolishing the messenger RNA due to lost functions. As a result, morphology associated with function is lost while the gene is retained, and this is sure to be inherited. "Lost character" and "acquired character" are equivalent for the living organism, but these terms are overlaid with values such as the teleology or anthropocentricism. As long as life science is discussed in these value-oriented terms it will be difficult to scientifically and biomechanically clarify life phenomena. The lost of characteristics that are no longer useful to an organism is indeed evolution for the living creature and constitutes a newly acquired character. These changes can be considered merely as a difference in the accumulation of biomechanical responses. Accumulation phenomena of these kinds are even now going on in the human brain, facial morphology, construction of the larynx and teeth, cecums, genital organs, pelvic form, tail and mammary gland, etc.

If these phenomena are promoted through natural selection by mutation alone, they seem to overlap too really with the simple direction of the mechanical responses in skeletons composed of collagen and apatite. Not only the basic construction of vertebrates, but the weak points of deviations in organisms should be understood in evolution from the standpoint of biomechanics. Then, adequate measures can be taken to maintain and promote human health.

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脊椎動物の基本体制と人体の構造欠陥および新しい免疫学の概念について

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和文抄録

脊椎動物の基本体制の確立は，半索類の幼形進化で起こっている。これは，呼吸・栄養・排出系を一本の腸管にまとめたことによる。哺乳類は，脊椎動物の進化の過程において，四種の劇的革命を経て生まれた。これらの進化の現象は，形態の生体力学対応による変容とみることができる。脊椎動物の基本体制に照らすと，人体の構造には形態と機能の観点から，進化を通じて種々の問題が生じている。

個体発生ー系統発生の形態学と生体力学，分子遺伝学を統合した観点から研究を試みた。これにより，免疫系も細胞レベルの消化として理解し，新しい免疫学の考えを試みた。