

Translation of Western Embryological Thought in the Edo Period: Tsuboi Shindō and Malpighi's Observations of Fertilized Eggs

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Rangakusha (Japanese scholars of Dutch learning) studied and translated numerous imported Dutch medical books in the late Edo period, but they have received less credit than they are due. It has been commonly supposed that they absorbed only practical knowledge, and were not acquainted with the scientific methodology or physiological ideas behind that knowledge. A closer look at some surviving medical manuscripts, however, reveals the opposite. This article focuses on the transmission of Western embryological ideas and their methodological background to Edo-period Japan, in particular the translation by Tsuboi Shindō of Malpighi's observations of fertilized eggs. These observations were cited in the Dutch translation of van Swieten's *Commentary on the Aphorisms of Herman Boerhaave*, a theoretical medical treatise that was imported to Japan at that time and translated by Tsuboi. This article is composed of two sections. The first section situates Malpighi's observations of fertilized eggs within the European medical context of that time and clarifies Tsuboi's background knowledge. In the second section I have analyzed Tsuboi's translation of Malpighi's observations and provided commentaries on the intellectual background of these passages.

Keywords: RANGAKU, TRANSLATION, HISTORY OF MEDICINE, HISTORY OF EMBRYOLOGY, MECHANISTIC THEORY, BOERHAAVE, VAN SWIETEN, MALPIGHI, TSUBOI SHINDŌ

Introduction

In the late Edo period, the *Verklaaring der Korte Stellingen van Herman Boerhaave, over de Kennis en Geneezing der Ziektens* (Commentary on the Aphorisms of Herman Boerhaave Concerning the Knowledge and Treatment of Diseases, 1763-76; hereafter, *Commentary on the Aphorisms*), was imported to Japan. This work was the Dutch translation of the theoretical medical treatise *Commentaria in Hermanni Boerhaave Aphorismos de Cognoscendis et Curandis Morbis* (1742-72) by Gerard van Swieten (1700-72), which was in turn a commentary on *Aphorismi de Cognoscendis et Curandis Morbis* (1709) by Herman Boerhaave (1668-1738), the founder of the Leiden School.¹ The scholar of Dutch studies Tsuboi Shindō 坪井信道 (1795-1848) completed an abridged translation into Japanese in 1826 under the title *Manbyō chijun* 万病治準 (Standards of Treatment for All Diseases).

Taking his cue from the success of contemporary mechanistic theorists, Boerhaave incorporated the fruits of the new Newtonian sciences into his own medical doctrine and attempted to explain the concepts of physiology and pathology in terms of simple mechanistic principles. One of the new disciplines by which he was influenced was the embryology of Marcello Malpighi (1628-1694). In *Commentary on the Aphorisms*, Malpighi's embryological

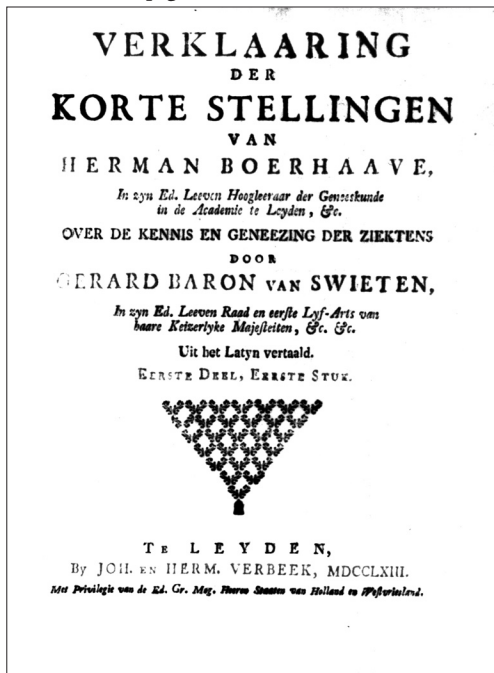


Figure 1. Title page of Boerhaave's *Verklaaring der Korte Stellingen* (1763). Library of the International Research Center for Japanese Studies.

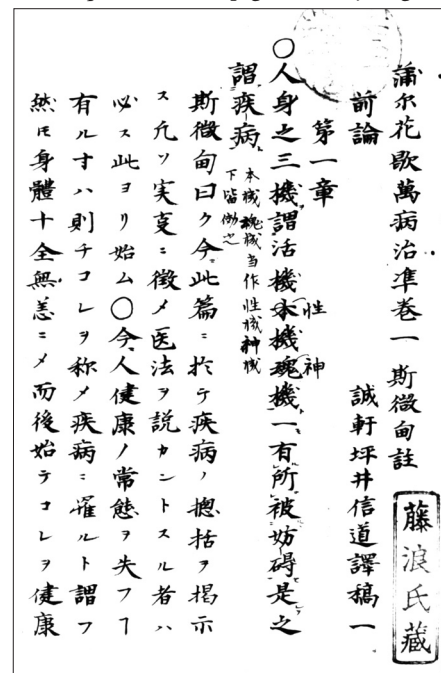


Figure 2. Opening page of Tsuboi's *Manbyō chijun* (1826). Kyōu Shooku Library, Takeda Science Foundation, Osaka.

observations of fertilized eggs are quoted at length in order to corroborate Boerhaave's theory. A translation of these observations appears in *Manbyō chijun*.

The fact that Malpighi's observations were translated into Japanese is significant because until recently it was supposed that only practical knowledge, and not high-level specialized learning that was in circulation among the most discerning European scholars, was absorbed by the *rangakusha* (scholars of Dutch studies). It is even more important to know that the translator was Tsuboi Shindō, an excellent teacher whose private academy Nisshūdō 日習堂 trained many outstanding physicians in Western medicine.

In order to convey an understanding of the importance of Tsuboi's translation, I need first to situate the significance of Malpighi's observations in the context of seventeenth- and eighteenth-century medicine; I will do so briefly in the next section of this article.

Section One: Malpighi's Embryological Treatises

1. The Tradition of Chicken Egg Observation in Europe

The tradition of observing chicken eggs in Europe is said to have begun with Hippocrates.² In the twenty-ninth chapter of the essay *De Natura Pueri* (On the Nature of Children), he wrote:

Take twenty eggs or more, and set them for brooding under two or more hens. Then on each day of incubation from the second to the last, that of hatching, remove one egg and open it for examination. You will find that everything agrees with what I have said, to the extent that the nature of a bird ought to be compared with that of man.³

Hippocrates' notion that we can understand the shape of growth by observing the contents of the chicken egg was valued by subsequent generations, but it was not until the Renaissance that someone emerged who would follow his example and actually perform this type of experiment.⁴ And indeed given that such recorded observations themselves are absent from the *Corpus Hippocraticum*, this quote from *De Natura Pueri* does not signify an encouragement of the principle of experimentation as a basis of learning, but rather must be taken as a statement the author used to argue his own proposition.

In the medical world of sixteenth-century Europe, there was a heightened interest in embryological observations. *De Formatione Ovi et Pulli* (The Formation of the Egg and of the Chick, 1621) by Hieronymus Fabricius ab Aquapendente (1533-1619) was the first published work to depict in illustrations the developmental process of chicks during incubation. However, even though Fabricius' treatise broke new ground, neither it nor many of the other recorded observations of that time advanced beyond the confines of scholasticism. Fabricius' pupil William Harvey (1578-1657) took a critical view of the contemporary referentialism in his *Exercitationes de Generatione Animalium* (On the Generation of Animals, 1651). He considered it "unsafe, and degenerate. . . to be tutored by other mens commentaries, without making tryal of the things themselves: especially, since Natures Book is so open, and legible."⁵ Nevertheless, *Exercitationes de Generatione Animalium* itself also contains many quotations

from Aristotle and does not break the mold of scholastic work. Yet in *Exercitationes de Generatione Animalium* one can also see many new records based on detailed observations concerning the development of the embryo that are more advanced than what Fabricius reported. In other embryological treatises of the latter half of the seventeenth century, one can also see the same insistence upon the principle of experimentation as one finds in Harvey. In his work *Novus et Genuinus Hominis Brutique Animalis Exortus* (New Theory on the Generation of Humans and Irrational Animals, 1661), Anton Everaert (died 1679) wrote:

Now I have always thought very highly of Harvey's experiments and accepted them as perfectly true. But that I might not forever be leaning on the experiments of others and perhaps be seduced by my credulity, I have therefore preferred to undertake dissections of my own, . . . and since it is not every day that the human body can be dissected, I have devoted myself to the examination of the fetuses of certain animals—dogs, hares, and so forth, and especially rabbits.⁶

The foregoing passage notwithstanding, Everaert's essay still contains many citations, beginning with Harvey and including Hippocrates and others.

2. Malpighi's Observational Methods and Views

In the observation of the developmental process of the chick, it was Malpighi who was able to completely rid himself of the scholastic tradition. Malpighi's microscopic observations of fertilized eggs are contained in two treatises that he submitted to the Royal Society of England, *De Formatione Pulli in Ovo* (On the Formation of the Chick in the Egg [Bologna, 1672]) and *De Ovo Incubato Observationes Continens* (Repeated and Additional Observations on the Incubated Egg [Bologna, 1672]).⁷ These are thorough observational records of the developmental processes of chicks within the egg; the many scholastic references that characterize other treatises of the same era are virtually absent. Malpighi's embryologic research is therefore significant as an early exponent of basic research based on pure observation without drawing premature conclusions from assumed premises.

For the purpose of these observations, Malpighi employed a microscope. Pioneers such as Harvey and others also utilized microscopes, but it is clear from Malpighi's letters that among Italian anatomists of the time, microscopic anatomy was already firmly established. In his correspondence with Giovanni Alfonso Borelli (1608-79), Lorenzo Bellini (1643-1704), and Nicolaus Steno (1638-87), the topic of microscopic observation appears frequently.⁸ In his writings, Malpighi enthusiastically promoted the application of microscopes in dissection. In *Opera Posthuma* (Malpighi 1697), he wrote that two looks through Galileo's telescope had revealed more things than had been seen in millenniums before, and the microscope had brought to light so many wonderful mechanisms and structures in animals that anatomy could expect to make great strides from its use.⁹ Based upon his belief that "the human body is a synthesis of microscopic instruments whose structures and movements cannot be seen with normal vision," Malpighi stressed the necessity of microscopic anatomy in the preface of his *De Viscerum Structura* (Structure of the Viscera, 1666).¹⁰

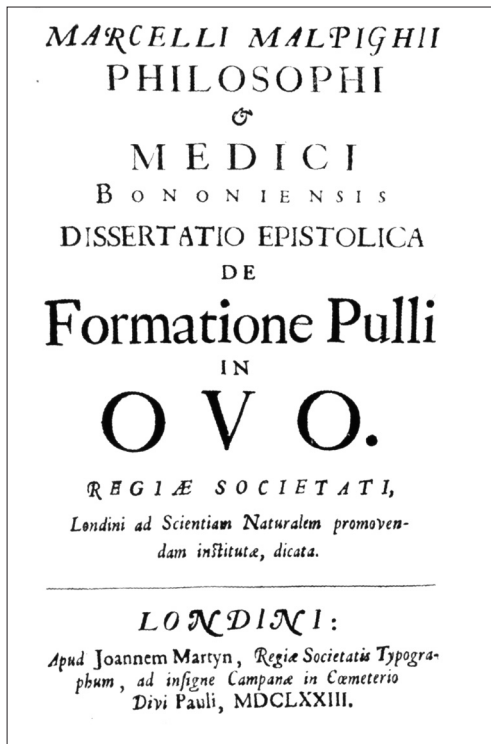


Figure 3. Title page of Malpighi's *De Formatione Pulli in Ovo* (1673). Library of the International Research Center for Japanese Studies.

Unfortunately, Malpighi left little information on his method of using the microscope. In *De Formatione Pulli in Ovo*, he mentions removing a piece of yolk sac and spreading it on glass.¹¹ There is no reference to the use of a microscope, but judging from the minuteness of the recorded observations and the references to microscopes in Malpighi's other writings, we can assume that he employed a microscope in preparing his treatises on the chick as well. Moreover, in his *Opera Posthuma*, he writes:

For many years I myself have endeavored to investigate generation in the hen's egg. . . . During the first years, I confess, I distinguished few details, so obscure and chaotic was the state of things, until after long practice, by devising my own method and discovering finally a way of removing the cicatrix¹² and spreading it out on glass, I was able to observe and to some extent distinguish the first filaments of the animal.¹³

It is likely that this very method resolved the various problems occasioned by observing the blastoderm in its original location, and enabled accurate and minute observation. However, what we ought to note here is the fact that the magnification of the microscopes employed by the famous microscopic scholars of that time was not very great. In particular, since the simple microscope had less optical distortion than the compound microscope and the resolving power of the latter was virtually unimproved from its invention around 1600 up to around 1830, it seems that most of the contemporary microscopic scholars preferred the simple microscope and used it in their studies. Incidentally, it is clear from Leeuwenhoek's exchanges with the Royal Society of England that the magnification of his simple microscope was far greater than that of the compound microscope used at the time.¹⁴ Malpighi also used both the simple microscope and the compound microscope at the same time. In his *Opera Posthuma* he writes that before using an instrument with greater magnification, one must first carry out observations under a simple microscope of lesser magnification.¹⁵

When we take into consideration the limits of the compound microscopes of that era, it is clear that even if Malpighi was aided by his innovative method of placing the blastoderm on glass, his revolutionary powers of observation were not solely the product of improvements

in the microscope. Rather, it was the revival of the ideas of *De Natura Pueri*'s author, namely, the very idea that “the nature of birds corresponds to the nature of humans” that exercised an important influence on his passion for observation. In a letter to Malpighi dated 24 April 1672, the secretary of the Royal Society of London, Henri Oldenburg (1618-77), commented about Reinier De Graaf (1641-73)'s *De Mulierum Organis Generationi Inservientibus Tractatus Novus* (New Treatise Concerning Female Reproductive Organs [Lugduni Batavorum, 1672]), which had been published in Leiden that same year:

The author tries to show that man and all the other animals called viviparous arise from eggs no less than ovipara do. He boldly asserts that he has himself often seen eggs of quadrupeds expelled from the testes and conveyed through the Fallopian tubes into the uterus, and he affirms that he can demonstrate the same thing any day.¹⁶

In his reply dated 7 June 1672, Malpighi indicated his agreement with De Graaf's theory:

But I think that the great man's position is a very probable one; for it is certain that eggs are to be found in the female testes, even in the young of animals shortly after birth, and that [the infundibulum of] the tube of the uterus has exactly the same conformation as the upper portion of the ovary; hence it is by this same passageway that the eggs enter.¹⁷

The very idea that the development of human embryos did not differ from the development of chicks undoubtedly was a strong impetus for examining the formation of the chick in the egg, and it lent Malpighi's dissertations a special authority.

3. Boerhaave and the Theory of the Heart's Preformation

While Malpighi poured all his energies into observation itself, as much as possible he left the interpretation of his observations to the reader. One of these interpreters was Boerhaave. Judging from the *Commentary on the Aphorisms*, Malpighi's observations concerning the formation of the heart and various blood vessels in the embryo were of particular concern to Boerhaave. In these observations Malpighi discusses whether the heart or the blood exists first. Boerhaave cited Malpighi's text here and there in the *Commentary on the Aphorisms*, and these citations are translated by Tsuboi Shindō, providing us with valuable evidence of the reception of Western embryological thought in Edo Japan. To assess that reception, I will, in this essay, compare Boerhaave and Tsuboi's texts. Before I do so, however, we need to examine Malpighi's original text. In *De Formatione Pulli in Ovo*, Malpighi describes the circumstances of his observations after the passage of forty hours in the following manner (the English translation is borrowed from Adelman):

It is very difficult indeed to establish by the senses alone whether or not the blood exists before the heart here described. For although a fuscous and rubiginous humor very frequently appears in the outer ends of the umbilical vessels before the heart has clearly come to view, and although it may seem plausible to assume that the heart is

formed from a bent and expanded vessel, to the outside of which fleshy parts embracing it like hands are fitted, nevertheless, since at that time everything is so mucous, white, and transparent that the eye, with whatever instrument it may be fortified, is unable clearly to detect the contexture of the parts, and inasmuch as we observe that in insects the rudiments of the parts found in the last phase are present in the earliest stages, I must still remain in doubt about the heart. This, however, is certainly obvious to the sight: the blood or sanguineous material does not have from the earliest stages all those things subsequently discovered in it; for at first there is visible in the vessels something having the appearance of colliquament conducted by rivulets toward the fetus; presently, as a result of fermentative action, a humor somewhat vitelline and rubiginous in color appears, which at length becomes red, and in these final stages is driven in a circle through the agency of the heart. We may therefore suspect that, just as successive alternations in the sanguineous material are revealed by the color it assumes, so, likewise, the structure of the heart is made evident solely by its motion, and that, although weak (because, of course, the fleshy fibers have not yet been made strong), the heart has existed before this time in a state of rest. This however, seems to be certain: the ichor, that is, the material I have mentioned that finally becomes red, exists before the heart begins to beat, but the heart exists and even beats before the blood reddens.¹⁸

In this passage, it seems that Malpighi is suggesting that while he has been unable to determine the existence of the heart by sight, in the course of his observations he has found evidence that the heart and other parts are preformed, even if they are still in an invisible state. The heart is preformed, but it becomes visible only when it begins to move. He grounds this hypothesis on the fact that he observed the sanguineous material gradually changing its color. As the sanguineous material changes to a red color, the structure of the heart finally becomes visible. The connection between the color of the blood and the existence of the heart may seem difficult to understand. This connection must be understood in the context of contemporary medical thought. It was believed that when food is eaten it first preserves its character, then as it passes through the various organs and blood vessels (which, at the time, were believed to be the digestive system) it is gradually transformed by the actions of these bodies into blood and nutrients. The role of the heart then is to receive the transformed sanguineous material and to pump it through the body as the engine of vital movements. This very idea explains the fact that Malpighi assumed that the heart had already existed in a state of rest. The heart was there, waiting for the blood; when it received the blood it could start to beat and finally become visible. From the text it is clear that Malpighi believed that the gradual transformation of the blood appeared in its color. As a result, in describing the color of the blood he uses such fine color categories as *subvitellinus* and *rubiginosus* in the Latin original. These changes in color as described by Malpighi attracted the attention of Boerhaave, who had built up his own physiological and pathological theory entirely on the idea of the transformation and movement of the humors in the body. Malpighi's description

is therefore adopted and dwelled upon in *Commentary on the Aphorisms*.

The question of the heart's pre-existence is dwelled upon by Malpighi in other essays as well. In *De Ovo Incubato Observationes Continens*, Malpighi once again raises the possibility of the heart's pre-existence as follows:

Hence I still cherish the conjecture that I have elsewhere advanced: perchance the juice, the vessels, and the heart pre-exist and gradually come to view, as we observe in the eggs of trees.¹⁹

In Malpighi's research on fertilized eggs, this proposition is one of the rare conjectures that are not based on observation. While he was unable to determine it by observation, the fact that, to the end, he leaves it as a conjecture while prudently expressing his doubts shows Malpighi's scrupulous stance on the principle of direct observation. However, the principle of direct observation that he established—in a break with scholasticism—eventually became one of the bases for a new doctrine of the body, namely Boerhaave's mechanistic theory of the body. In other words, according to Malpighi, while the heart is observed at the time when the blood becomes visible, at the time when the heart is still invisible the blood is also still invisible, but the fluid that becomes the blood is already observed. Based upon these observations, Boerhaave came to the conclusion that blood was created from fluid (namely the food absorbed by human beings) through the actions of the various blood vessels and organs, including the heart. Boerhaave regarded the human body as a mechanism created by God, whose working could be fully understood by the science of mechanics.²⁰ Since regarding the human body as a mechanism includes the preformation of the heart and blood vessels as a necessary condition, Boerhaave accepted Malpighi's conjecture as an established theory. In *Commentary on the Aphorisms*, this type of reference to Malpighi's observations is repeatedly used to support this theory.

4. Knowledge of Chicken Egg Observation in Edo-Period Japan

As described above, in his treatise *De Mulierum Organis Generationi Inservientibus Tractatus Novus*, De Graaf asserted that "the origin of all animals including humans is, like birds, in eggs."²¹ This revolutionary notion had been conveyed to Japan via the anatomy book *De Nieuw Hervormde Anatomie, ofte Ontleding des Menschen Lichaams* (New Revised Anatomy, 1686) by Steven Blankaart (1650-1702). For the most part, Blankaart faithfully adopts De Graaf's theory in the two sections dealing with the female reproductive organs in "Part number 27: Concerning the female reproductive organs" (Het Seven en Twintigste deel Handelende Van de Vrouwelyke Teel-deelen) and "Part number 28: Concerning propagation from eggs" (Het Agt en Twintigste deel Handelende Van de Voort-teeling Uit Eijeren). In these essays, Blankaart gives a detailed explanation of the ovaries (eijernesten), eggs, and the growth of the embryos within them. Tsuboi Shindō's teacher Udagawa Genshin 宇田川玄真 (1769-1834) was acquainted with Blankaart's explanation. In Udagawa's physiological textbook *Ihan teikō* 医範提綱 (Complete Medical Teachings, 1805), we can find an abridged version of this explanation in the chapter "Shikyū" 子宮 (The Uterus):

All living things are, without exception, born from eggs. There is only a difference in whether they develop within the mother's body or develop outside that body. What is called viviparous is the egg that develops within the mother's body. To call it oviparous means that the egg develops after it has emerged out of the body. However, not only living things but also the seeds of plants are a kind of egg; they are things that develop within the earth.²²

In this brief text the belief that human beings develop from eggs in the same way as birds is clearly transmitted. Since *Ihan teikō* was by far the most widely read textbook on Dutch medicine at the time,²³ it can be assumed that this idea was already broadly accepted in medical circles at the beginning of the nineteenth century. Furthermore even the link is laid with the development of the seeds of plants, an idea Malpighi states frequently in his treatises and letters. This idea is also mentioned in Blankaart's anatomy work.²⁴ In chapter 28 of *New Revised Anatomy*, in which he describes the female's eggs, Blankaart uses Malpighi's observations to explain the development of the embryo within the egg:

One can see within the as-yet unincubated chicken egg that a long, small body appears, which after it has been incubated for a number of hours, receives a small head. After that, one can see several bumps on both sides of the spine. When twenty-four hours have passed, one can see the bubble-shaped brain and a part of the heart. After two days one can see the heart beating, and several vesicles appear, which are both of the edged cavities with the auricles. The brain also gradually solidifies and the arms and legs begin to emerge and this continues until all of the parts within the embryo appear.²⁵

In this summary Blankaart mentions the appearance of the heart after twenty-four hours have passed. In his own observation records, however, Malpighi states that "Although I thought I detected the motion of the heart, I nevertheless dared not affirm it with certainty."²⁶ In other words, Blankaart describes the appearance of the heart as an observed fact, while in Malpighi's text, it is put forward as a conjuncture. Blankaart was like Boerhaave a mechanistic theorist. Apart from the description of the heart, however, Malpighi's observations are rendered faithfully and the reader can get a coherent idea of the development of the embryo grounded on direct observation. This summary is not inserted in *Ihan teikō*, but it is quite possible that Udagawa had translated it in *Ensei ihan* 遠西医範 (ca. 1798), his unpublished compilation of Western anatomical and physiological texts.²⁷ Unfortunately, the manuscripts dealing with propagation are missing. A translation by another medical scholar still exists, however: in *Blankaart kaibō zusetsu* 蒲朗加兒都解剖図説 (Blankaart's Illustrated Anatomy, manuscript ca. 1801), by Koishi Genshun's 小石元俊 (1743-1808) pupil Saitō Hōsaku 齋藤方策 (1771-1849), we read:

I have once broken open an egg and looked (at the inside). At first I saw a long shaped body, but after a while I could see the appearance of a small head. After this I saw some bumps on both sides of the spine. Subsequently, after eight [sic] hours, I could

see the brain and a part of the heart added. Two days later, the heart beats, various vesicles originate, and both ventricles and both auricles come into existence. After this the brain also becomes stronger and the arms and legs appear for the first time. Then, after that, a variety of parts are formed, and everything displays vital energy.²⁸

Saitō's translation circulated in manuscript form. It demonstrates, together with Udagawa's texts, that by the beginning of the nineteenth century—well before Tsuboi started his translation of Malpighi's citations in *Commentary on the Aphorisms*—two important ideas were already established in Japan: that an analogy could be made between the embryos of birds and humans, and that embryological knowledge could be gained from the examination of chicken eggs.

Section Two: Tsuboi Shindō's Translation of Malpighi's Observations

In the *Commentary on the Aphorisms*, Malpighi's recorded observations of fertilized eggs are quoted to support Boerhaave's theory of the body's development, the theory of blood creation, and the theory of nutrition. In order to elucidate how Malpighi's observations were assimilated by Boerhaave and how they were subsequently received in Japan through the medium of Tsuboi Shindō's work, I will arrange my analysis according to these three subjects, beginning with the theory of the body's development. In the body of this essay I present my own English versions of the relevant passages; I have placed original Japanese and Dutch texts in the notes.

1. Theory of the Body's Development

Regarding the development of the body, Boerhaave says in the *Commentary on the Aphorisms*:

Indeed, an adult weighing 200 pounds was, at the time of his origin, hidden within a wavering drop of foam, and then from that small body he grew to such a great weight (p. 37).²⁹

In this way, the problem of the body's development is first introduced as a sort of a mystery. But directly after this lyrical introduction, Boerhaave tries to explain this phenomenon in a mechanistic way. He believed that the body's development was made possible by the continuous supply of nutrition by the fluids. The *Commentary on the Aphorisms* shows that the basis for this belief was Malpighi's observations.

All of the expansion in the solid parts is supplied through the fluids. This is what Malpighius observations of fertilized eggs teach us, and those observations were already carried out by Hippocrates. (From these observations it is clear,) that a chick that already possesses strong solid parts, grew from an invisible small body in less than twenty-one days due to the albumen's diluted liquid (p. 38).³⁰

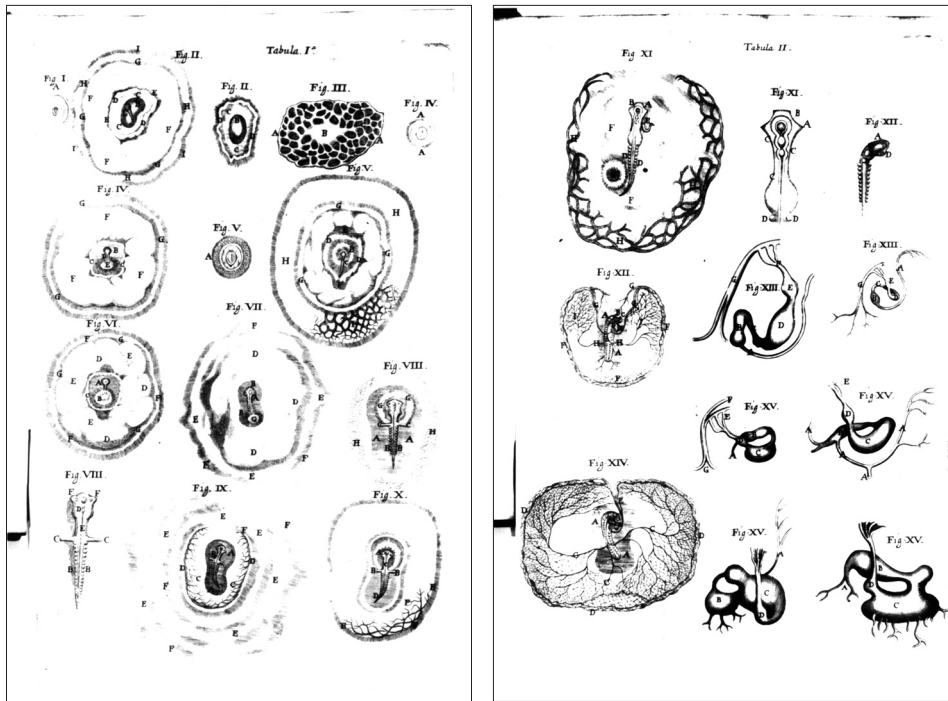
The reference to Hippocrates indicates chapter 29 of *De Natura Pueri*, and exemplifies Boerhaave's predilection for citing ancient authorities. The title of his work itself is reminiscent of the *Aphorisms* of Hippocrates. Boerhaave aimed at the establishment of a new system of medicine that would be comparable to that famous work. Perhaps as a consequence, we find an extremely large number of citations from Hippocrates in the *Commentary on the Aphorisms*. However, the observation records that Boerhaave actually uses for reference are those of Malpighi. Indeed, in Malpighi's *De Formatione Pulli in Ovo*, he describes how in the various stages of his observations the substance surrounding the scutellum ("cicatricula") is filled with fluid and develops into innumerable rivulets (rivulis) that convey that fluid to the scutellum and the amnion.³¹

Tsuboi Shindō accurately translates the foregoing passage as follows:

Now, if one provisionally takes the average body weight of an adult human being to be 200 pounds, when one traces it back to its origin, it was no more than something that existed hidden in a single wavering bubble. Though we can say that such an extremely conspicuous solid body developed from such an extremely infinitesimal thing, when we look for its origins there is no other conclusion than that the smallest basic substances are transported day and night by the blood and gradually become interconnected with one another. This became very clear when Malpighius (name of a person) once did an experiment when a hen was incubating its eggs. Hippocrates also tested this before him. According to his book, when a hen sits on his eggs, in just thirty-seven [sic] days the egg incubates and develops into a chick. When it has already become a chick, its body is very solidly developed. There is no other conclusion than that in the space of thirty-seven [sic] days, the chick's body has developed within the egg from the dilution of just a small quantity of the albumen's liquid.³²

In this passage, the European tradition of experimental observation of fertilized eggs represented by Hippocrates, Malpighi, and others who are introduced in connection with Boerhaave's medical theories. Note that Tsuboi transliterates Malpighius in *katakana* and adds an explanation that this is the name of a person: 「マルピギウス」(人名). This indicates that the name of Malpighi was new to him. On the other hand, characters are used for Hippocrates: 依卜加刺得私. Hippocrates became well known to the *rangakusha* as the father of Western medicine through the importation of various Dutch medical and historical books. Tsuboi was one of many Japanese admirers of Hippocrates, and even wrote some poems in praise of him.

Further Tsuboi refers to "basic substances" (*genjitsu* 元実). This term is not present in Boerhaave's original text, but is mentioned in other passages. *Genjitsu* is Tsuboi's translation of Boerhaave's *hoofdstof*, a term denoting the smallest indivisible basic elements of which the body is composed. Following Boerhaave, this basic substance at first does not make a solid body but flows independently through the fluids of the body. Becoming interconnected with other basic substances at a certain stage, it creates solid body, and doing so, brings about the development or sustenance of the body. Tsuboi's use of *genjitsu* in this case thus demonstrates that he had a good understanding of Boerhaave's development theory.



Figures 4 and 5. Drawings of the development of the chick in Malpighi's *De Formatione Pulli in Ovo*.

On the basis of the fact that Malpighi frequently refers in *De Formatione Pulli in Ovo* to small rivulets of fluid that flowed to the scutellum from the substance surrounding the scutellum, Boerhaave concluded that the development of the chick's body was carried out by the albumen's liquid. In addition, concerning the homogenization of the albumen's liquid, he remarks:

But the liquid of the albumen must be further diluted and made complete by the chick embryo's interconnected instruments [i.e. organs], before it could pass through those tiny vessels, which by their smallness surpass all comprehension (p. 38).³³

Tsuboi Shindō translates this passage as follows:

However, as for the white liquid within the egg, when the chick is developing into a solid body, it must necessarily pass through the narrow vessels of the body and transform itself [into a substance of the solid body]. But since these vessels are extremely small, there is no way for the coagulated fluid to pass through it. Therefore, before passing through the vessels and transform into solid body, the liquid must be dissolved and diluted by the functions of the various organs within the chick's body.³⁴

Here again, Tsuboi does not stick to a literal translation but explains Boerhaave's theory

accurately. Boerhaave holds that the albumen that serves as nourishment transforms into solid body as a result of the working of the “interconnected instruments.” “Interconnected instruments” is a direct rendering of the original Dutch *samengestelde werktuigen*, but at the time this term was widely used to express the various organs of the body. The term naturally was used by mechanistic theorists such as Boerhaave, who saw the human body as a machine composed of several interconnected instruments that formed a sort of perpetuum mobile.

In the Dutch-Japanese dictionary *Edo Halma*, heavily used in the Edo period, there is only one translation for *werktuig*: *kikai* 器械 (instrument). The *Nagasaki Halma* that Tsuboi Shindō is said to have copied gives *saiku dōgu* 細工道具 (tool) as a translation for *werktuig*, and the model sentence below it, “de daaden der dieren geschieden, volgens Descartes werktuiglijk,” is translated as “according to Descartes’ theory, the actions of living beings is something that resembles the artifice of instruments.”³⁵ From this it is clear that Tsuboi was acquainted more or less with the mechanistic idea that the human body is like a machine, composed of several instruments. In his translation of Boerhaave’s term *samengestelde werktuigen*, however, Tsuboi does not give a direct translation, but accurately interprets this term as “functions of the various organs” (*shoki no kinō* 諸器ノ機能).

2. Theory of the Human Body’s Creation of Blood

In *Commentary on the Aphorisms*, the idea that the human body creates blood is clearly described:

The human body creates for itself blood from a substance that is not blood. And there is no difference whether the human body is small and almost in the earliest stage of its existence or whether it is already grown-up and strong. The existence of the blood is so inseparable from the determined nature of the human body, that it exists in the weakest child as well as the strongest man. Indeed, in the very human embryo, at the stage in which it becomes visible to the eye, red blood already exists and certainly at the time, when not in the placenta, nor in the membranes of the human egg, nor in the liquid that is contained in these membranes, one finds any sign of red colored blood. From this it is evident that the human body is the creator of blood, even in that fragile and mucous rudiment (pp. 253-254).³⁶

Tsuboi renders this passage as follows:

The faculties of the human body create skillfully blood from things that are not blood. Moreover, there is no difference between infants or adults. There is no distinction between the strong and the weak. All, without exception, have blood. In addition, when the embryo is first residing within the mother’s body, from the outset it is already provided with red blood. However, at this point, no matter how hard one tries, one cannot see red blood in the placenta, the embryo membrane, or the amniotic fluid. Based on this, when we observe this, the first appearance of the embryo’s red blood is created by itself through the organs in the embryo’s body, and blood is not something

that comes from the mother's body. We should realize that what creates a human body's blood is, namely, that person's body, and even in the extremely fragile and weak embryo it is skillfully creating red blood through the functions of its own body.³⁷

In this translation, Tsuboi accurately conveys Boerhaave's fundamental physiological concept that the human body creates its own blood. The problem of the creation of the blood—whether it occurred in the embryo due to the supply of blood from the mother, or it was developed directly by the embryo itself—was a question that was still fiercely discussed in Boerhaave's time. Tsuboi's wording “the first appearance of the embryo's red blood is created by itself through the organs in the embryo's body, and blood is not something that comes from the mother's body”³⁸ is not a direct translation of the original text, but it displays a thorough understanding of the meaning of Boerhaave's theory. In this sentence, Tsuboi translates “the determined nature of the human body” (*de vastgestelde natuur van het mensche-lijke lighaam*) as “the organs within the embryo” (*taichū no kikan* 胎中ノ機関); this is a good interpretation, as the term *natuur* was generally used by the mechanistic theorists to denote the organs of the human body. The concept that the human body is the creator of the blood is therefore accurately expressed in Tsuboi's translation.

In *Commentary on the Aphorisms*, Boerhaave seizes upon Malpighi's observations of fertilized eggs to prove that the blood is already created at the embryonic state.

When now in a human beings' earliest rudiment red blood begins to originate is not easily determined through experimentation. However, the immortal Malpighius has proved this case in an incubated egg (p. 254).³⁹

Tsuboi puts this passage in slightly terser language:

It is extremely difficult to investigate the first existence of red blood in the embryo, but Malpighius (name of a person) clarified this in chicken eggs.⁴⁰

To prove his theory of blood creation by the various organs of the human body, Boerhaave gives a long and detailed citation of Malpighi's observations in *Commentary on the Aphorisms*. Below, I analyze this citation together with Tsuboi's translation along four themes: the composition of fertilized eggs at the initial state; the observation of blood, the heart, and various blood vessels; the heart's preformation; and the role of the lungs in the process of blood creation.

1) **Description of the Structure of the Blastoderm in Unincubated Eggs**

Commentary on the Aphorisms begins with a description of the structure of fertilized eggs, which are not yet incubated.

A fertilized egg that has not yet been incubated, show in their shell membranes, the albumen, the ovary (*Chalazae*), the yolk, a membranous, nutritive saccule (*Sacculus colliquamenti*), no red blood yet, even if one observes it with the best magnifying glasses (p. 254).⁴¹

This passage is clearly based on Malpighi's description in *De Formatione Pulli in Ovo* of eggs laid the previous day which are not yet incubated. Although Malpighi's description is far more detailed than Boerhaave's summary, we must be aware of the fact that Malpighi only possessed low magnification microscopes, making the blastoderm largely inscrutable and leaving plenty of room for speculation.⁴² Boerhaave's conclusion that no blood could be discerned is an example of such speculation. The translation of this portion by Tsuboi is concise, and the explanation concerning the initial structure within the unincubated egg is abbreviated. Tsuboi includes in his version only the statement that red blood cannot yet be found in the initial stage.

When one breaks open an as-yet unincubated chicken egg and looks within, red blood cannot be seen even when looking with a high-quality microscope.⁴³

Tsuboi Shindō translates the original text's *vergrootglas* (literally magnifying glass) as *kenbikyō* 顕微鏡, a term that denotes the compound microscope and was already commonly known among the scholars in Tsuboi's time. From the 1780s on, *kenbikyō* and other terms meaning microscope began to appear frequently in Japanese sources. The *mikorasukōbyun* ミコラスコーピュン mentioned in Morishima Chūryō's 森島中良 (1754-1810) *Kōmō zatsuwa* 紅毛雑話 (Red-Haired [Dutch] Miscellaneous Stories) is a typical example of this.⁴⁴ In Ōtsuki Gentaku's 大槻玄沢 (1757-1827) *Chōtei kaitai shinsbo* 重訂解体新書 (Revised New Book of Anatomy, 1822), which is an annotated translation of Johan Adam Kulmus' *Ontleedkundige tafelen* (Anatomical Tables, 1734), not only is the passage concerning the use of the microscope in anatomy duly translated,⁴⁵ but also a picture of a compound microscope is inserted as the frontispiece. This symbolizes the understanding among the *rangakusha* of the importance of the microscope. Not only were microscopes imported, from the end of the eighteenth century they were also constructed throughout Japan in such places as Osaka and Nagasaki.⁴⁶ It is possible that Tsuboi himself possessed a microscope, although unfortunately there is no material evidence that would prove this.

2) **The Observation of Blood, the Heart and Various Blood Vessels**

In the *Commentary on the Aphorisms*, observations of blood, the heart, and various blood vessels are described thus:

Changes within the incubated eggs were observed nearly every hour, and in the area of the nutritive saccule [*cicatricula*] near the yolk, appeared already through the magnifying glasses some visible vessels; some hours thereafter, the vessels became distinguishable from the fluid contained within them; about the thirtieth hour, these vessels got a greenish color; about the fortieth hour there was a rust color (called withered vine leaves color [*Xerampelinum*] because vine leaves have this color in autumn) also, it became clear that the aggregation of all of these vessels was flowing toward a single vessel, which extending to the position of the nutritive saccule ended in a certain bosom that was only just then visible; this bosom was the right auricle

of the heart, as it later became clear; and in this bosom hanging down from the bent body [*Carina*], pulse was clearly observed; and shortly thereafter, a red spot became visible in this small, pulsing body. This same red (color) was next observed in both the right and left ventricles of the heart, and also in a vessel running along the length of the bent body, which was the aorta (p. 254).⁴⁷

Tsuboi Shindō translates this portion down to the smallest details:

Thereafter, when the hen incubates it, the inner structure changed gradually every hour, every day. In the beginning, first, in the area of the yolk where the “voedzel-zakje” (the name of the membrane in the egg) is, one could clearly see with a microscope that there were already one or two blood vessels. Upon looking at this after a short time has passed, the blood vessels and the liquid contained within the blood vessels were distinguishable for the first time. After fifteen hours have passed, the aforementioned blood vessels turn a green color, and on the fourteenth [sic] hour they had already turned the color of iron (iron color is also called withered vine color, because the vine leaves turn this color until autumn). After this, the blood vessels mentioned earlier came together to form a single vessel. This vessel emerged from the area of the “voedzel-zakje” (see above) and ended in a rather wide, open space. This wide, open space was, in other words, the right auricle. This auricle hung down from a bent, small body. Soon thereafter pulse occurred clearly in this auricle. After another passage of time, a red spot could be seen on the place where there was pulse. Again after a short time, one could see also a red spot like the one just before in the left and right ventricles of the heart. This red spot flowed through the bent body forming an elongated shape. This bent shape was, that is to say, the aorta.⁴⁸

The foregoing passage is a summary of the observations in Malpighi’s *De Formatione Pulli in Ovo* up to the fortieth hour. While Malpighi’s descriptions are much more general and cautious, expressing doubt as far as interpretation is concerned, Boerhaave entirely focuses on the emergence of the heart and various blood vessels, and takes Malpighi’s speculation as ocular proof that the heart pre-exists and that the blood is from the outset produced by the body. Tsuboi’s translation of course expresses Boerhaave’s statements faithfully.

In the Dutch language edition of *Commentary on the Aphorisms*, *cicatricula* is translated into Dutch as *voedzel-zakje* (nutritive saccule). This translation of *cicatricula*, meaning nowadays the germinal region of an egg,⁴⁹ is an indicator of the contemporary confusion in the use of specialized terms. According to Adelman, up to the sixth day of incubation Malpighi refers sometimes to the whole blastoderm and sometimes to the area *pellucida* alone as the *cicatricula*. In his *Anatome Plantarum*, Malpighi supposed that in all eggs with which he was acquainted the *cicatricula* probably contained the framework of the animal, less unfolded in some, more manifest in others.⁵⁰ The translation of *cicatricula* into *voedzel-zakje* suggests that the Dutch writer may have mistaken it for the *sacculus coliquamenti*. His addition of the Latin term in brackets signals that he was not sure of his translation.

Apparently Tsuboi did not understand the meaning, either, because he resorts to the *katakana* syllabary and transliterates *voedzel-zakje* as フートセルサッキー, rather than committing himself to a Sino-Japanese equivalent. The term “nutritive saccule” is easy to translate directly, but Tsuboi Shindō does not. Rather he adds his own interpretation: “the membrane within the egg” (*ranchū no maku* 卵中の膜). If we translate this back into Latin, it would mean the amnion. Tsuboi’s interpretation may be due to the influence of *Ihan teikō*. *Ihan teikō* mentions that “there is a small membranous saccule in the ovary” (*ransōchū ni shōmakunō ari* 卵巢中ニ小膜囊アリ).⁵¹ This statement is based on “Concerning propagation from eggs,” the twenty-eighth chapter of Blankaart’s *New Revised Anatomy*, on which Udagawa Genshin had drawn heavily in the composition of *Ihan teikō*. In this chapter Blankaart explains that “the membranes of the chorion and amnios are also already in the egg and create together with the embryo a small body.”⁵²

As I mentioned earlier, Malpighi regarded the color of the fluids as important in the confirmation of the blood’s existence. The changes in color, which Malpighi describes minutely, are faithfully adopted in the *Commentary on the Aphorisms*. The description of the vessels turning a greenish or xerampelinus color closely follows Malpighi’s original text, which reads: “The heart (E) pulsated, having received from the veins a humor rubiginous or sometimes the color of withered vine leaves.”⁵³ Tsuboi Shindō’s translation of these colors is accurate. The gradual change of the color of the fluids is an argument which Boerhaave seized upon to prove that the colliquament is transformed within the body by the agency of the heart and the vessels into blood. According to Adelman, these changes in color primarily reflect the gradual increase in the amount of hemoglobin contained in the cells of the anglioblastic cord and later in the freed embryonic erythrocytes.⁵⁴

The “bosom” (*boezem*) used in the *Commentary on the Aphorisms* indicates the ventriculum used in *De Formatione Pulli in Ovo*, meaning the heart’s right ventricle. Until confirming it to be the right ventricle, Malpighi describes this as a vesiculus, or “small fluid-filled sac.” Tsuboi Shindō translates it as “a wide open space” (*kūkatsu naru tokoro* 空潤ナル所). The only term that Tsuboi Shindō did not understand very well was the “bent body (*Carina*)” (*het gebogen lighaamtje* [*Carina*]). Probably the Dutch translator did not understand the term either, judging from his vague translation and his adding of the Latin term in brackets. This term was used by Malpighi and others to denote the first rudiments of the spinal column in a chicken’s embryo, because it is bent in the form of the keel of a ship.⁵⁵ Tsuboi translates this term in a neutral fashion as “a bent thing [body]” (*kyokkei no mono* 曲形ノ物).

Finally, concerning the time of observation, Tsuboi is using fifteen hours for Boerhaave’s thirty hours and fourteen for Boerhaave’s forty hours. Fifteen hours is correct, because one Japanese hour was equal to two European hours. Fourteen hours, however, is a mistake; almost certainly the error occurred when the manuscript was copied, for another manuscript, in the possession of the late Achiwa Gorō, mentions twenty hours.⁵⁶

3) **The Heart's Preformation**

Summing up the foregoing observations of the heart and various blood vessels, Boerhaave concludes:

From this, we know that from a substance that is not red in color, red blood can emerge, and moreover, without the slightest admixture with a substance that is already red blood. The origin of this red [color] is in that pulsating little spot, because it [=this red color] is only for the first time observed in the place where there is pulsation, and there is already red blood before any bloodlike color can be seen in the rudiments of the chick's liver. As a result, the belief of the ancient physicians, who attributed the function of blood creation to the liver is refuted (pp. 254-255).⁵⁷

Tsuboi Shindō translates this passage as follows:

From this, when one examines this, it is clear that even those things that at first were not red change gradually and become red blood. Moreover, there is no doubt that although there is no admixture with blood that has already become red, it generates blood very well by itself through its natural functions. Therefore, the origin of red blood begins in the heart's right auricle. The doctrine of the ancients that the blood was generated by the liver, was a great mistake.⁵⁸

Boerhaave's mentioning of a pulsating little spot (kloppend stipje) again has its origin in Malpighi's observations. In *De Formatione Pulli in Ovo*, Malpighi states, "I think, then, that these successively pulsating vesicles are the true heart; around them (as I have more than once indistinctly observed) were drawn fleshy, muscular parts that had not yet become opaque or red. That motion which has elsewhere been observed in the 'sparkling drop' or 'leaping point' is therefore, I believe, by no means the palpitation of the blood contained in it, but the motion of the true heart."⁵⁹ Boerhaave takes this passage as the basis for his proposition that the heart of the embryo beats before red blood is present, while Malpighi is still in doubt on this subject. Boerhaave goes a step further and attributes the blood's origin to the working of the heart. He does not expressly mention the heart, but it is clear that he assumed that the red spot was indeed the heart. Tsuboi's translation, "Therefore, the origin of red blood begins in the heart's right auricle" (*yue ni sekketsu no kigen wa kokoro no uji ni hajimaru 故ニ赤血ノ起原ハ心ノ右耳ニ始マル*), is testimony that Boerhaave's text can be interpreted in that way.

When "the ancients" are mentioned in the *Commentary on the Aphorisms*, of course the reference was primarily to Galen, and it was Galen's conviction that the liver was the organ that produces the blood. This theory had been refuted well before Boerhaave wrote his *Aphorisms*, and Malpighi's embryological observations had reconfirmed the refutation. In *De Formatione Pulli in Ovo*, Malpighi reported that when the fourth day had passed, at a moment when the primordium of the liver was clearly to be seen, the blood propelled through the arteries was already tinged a rich red, but still mucous (*sanguis per arterias propulsus rubicundo. . . Interius icoris inchoamentum. . . mucosa tamen, manifestaban-tur*).⁶⁰

4) **The Role of the Lungs in the Process of Blood Creation**

Boerhaave again bases his theory on Malpighi's observations as he discusses the action of the lungs upon the blood.

The air, without which neither plants nor animals could exist, may have some influence, because Malpighius observed that on the eighteenth hour of incubation, the location of the nutritive sacculle [*voedzel-zakje*] moves towards the obtuse angle of the egg where there is air. In adults the chyle that transforms into blood, flows directly through the lungs, where it is almost exposed to open air over an extremely wide area within extremely fragile blood vessels. In the belief of the ancient alchemists, the concealed principle of life [*verborgen beginzel des levens*] was hidden in the air (p. 255).⁶¹

Here the reference to Malpighi's observations is to *De Ovo Incubato Observationes Continens*.⁶² As Tsuboi Shindō rendered it:

Plants, trees, birds, animals, insects, fish, all cannot grow without air. For the function of blood production in the body, the aid of air is necessary. When Malpighius (see above) once broke open a chicken egg that had been incubated for eight [sic] hours and looked at the contents, the *voedzel-zakje* (see above) was moving towards the obtuse top of the egg. This obtuse top is the place where the air is enclosed. After an animal is born and is able to eat and drink by itself, the chyle that originates in the stomach and intestines passes through the veins and the right auricle and directly reaches the lungs, where it is acted upon by the lungs. This is because air is passing ceaselessly through the lungs, and since, moreover, the various vessels in the lungs are supple and thin, the fluid that passes through them is almost exposed to air. We ought to know that the lungs assist in the process of blood creation. According to the ancients, it was said that in air is hidden that what can be called the origin of life.⁶³

Concerning the role Boerhaave attributed to the air and the lungs in the process of blood creation, Tsuboi already had some background knowledge through *Ihan teikō*, in which Udagawa said of the action of the lungs:

Therefore, when the *ki*, which was inhaled through the trachea, fills the vesicles [of the lung], that *ki* passes through the narrow branches of the vessels and enters the blood. Thereupon the blood, combined with *ki*, is fermented and diluted, and becomes capable of flowing on its own.⁶⁴

I have deliberately transliterated, rather than translated, the word 氣 as *ki*, because it is clear throughout *Ihan teikō* that Udagawa used this term in the sense it carried in the framework of traditional Chinese medicine. For Japanese intellectuals by the time Udagawa and Tsuboi were active, however, this term also denoted air. Udagawa's explanation of the role of the air in the process of blood creation is also based on the *New Revised Anatomy*. Blankaart believed that the air pressed the blood in order to dilute it and further that the blood became

fermented and effervescent due to the fact that some substance of the air (which he thought to be saltpetre) was amalgamated with the blood.⁶⁵

5) **Conclusion**

Having described the transformation of blood within the body, basing a good deal of what he says on Malpighi's observations, Boerhaave concludes:

However, also in adult human beings blood is created from absorbed foodstuffs in about the same manner: because the lacteal vessels absorb the chyle formed in the intestines in the same manner as the vessels of the yolk absorb the albumen, which was diluted due to the heat of incubation. All of the chyle gathers in one lacteal duct. Thus, in chicks as well, all those vessels gathered in the amnion. Through the heat of incubation, the movement of the fluid through the blood vessels, the power of the heart, the compressing action of the air, there appeared within forty-eight hours red blood in a chick that did not have red blood: in a healthy adult human being chyle transforms into blood within twenty-four hours, as the observations of Lower and Waleus have taught us: and the transformation of chyle into blood in an adult human being is due to the combined effect of the heat of the body, the action of the heart and the various blood vessels, and pressure of the air upon the chyle that flows with the blood through the lungs: the fact that this transformation takes place in a shorter span of time in an adult human being than in a growing chick seems to be due to the more powerful action of the various blood vessels upon the therein contained fluids, respiration, and the large amount of blood that already exists (p. 255).⁶⁶

Tsuboi Shindō's version clearly expresses the notion that the process of blood creation in the human body occurs in accordance with the same principle as blood creation in the body of a chick within the egg.

The creation of blood as a result of an adult's eating and drinking follows largely the same logic as the creation of blood in the egg. This can be explained by the fact that the absorption through the lacteal vessels of the chyle, which was produced in the intestines and its conveyance into the blood is the same as the albumen of the chick's egg is diluted due to incubation and is absorbed through the small vessels in the area of the yolk and transforms into blood. As a result of the heat of incubation, the movement of the fluids through the vessels, the powerful working of the heart and the assistance of the air, red blood is generated within twenty-four hours. In a healthy adult the chyle is transformed into blood within twelve hours. This is because in an adult all of the various functions are strong, there is respiration, and there is already much red blood that exists within the body, the generation of blood is faster than in the case of the fluid in the egg.⁶⁷

Readers of Tsuboi's manuscript—which was circulated in his private academy Nisshūdō and beyond, and came to the attention of many late Edo-period intellectuals—could get a

clear sense of the importance of Malpighi's observations of fertilized eggs to the physiological knowledge of Europe.⁶⁸

3. The Albumen's Nutrition and the Principle of Life

I would like to touch upon one more citation concerning the observation of chicken eggs, because it sheds some light on the contemporary ideas concerning the principle of life. Based on Malpighi's observations, Boerhaave refers in the *Commentary on the Aphorisms* to the similarity between blood serum and the albumen and recommends the intake of eggs in order to strengthen weak organs and blood vessels.

Hiding many miracles beneath its fragile shell, the egg that has enlightened us so much about the reproduction of animals through the observations of the immortally famed Malpighius can also be used for this use [i.e. the intake of nutrition]. The albumen of the egg, which shares many characteristics with human whey [i.e. blood serum], contains a certain substance, which transformed due to the heat of incubation, let grow the hidden principle of life of the chick [verborgen levens be- ginsel] in the membranous saccule, in which the fragile fetus is contained with its first nourishment [*Sacculus Colliquamenti*], within twenty-one days into such a big body, because the yolk is not absorbed, only the albumen appears to serve as nutrition for the chick in the egg (pp. 59-60).⁶⁹

Tsuboi translates this passage as follows:

Although the chick is within a thin fragile eggshell, it is very clear from the experiments of Malpighius that it possesses magical vital functions. Therefore, we must know that it is used successfully for these symptoms. The albumen of the chick is of the same nature as the *weij* [serum] in human blood, and it contains within a substance that forms the body of a living being through the heat of the mother's body. The origin of the chick's body exists hidden within the egg together with the nutritive liquid, and after twenty-one days have passed the chick's body is completely formed. In other words, the nutritive liquid that is necessary during incubation is called the albumen. Because with the growth of the chick's body within the egg's shell, all of the albumen gradually extinguishes.⁷⁰

This translation does not do a good job of conveying the idea that many things in embryology have been clarified by means of the observation of eggs (in Boerhaave's phrase, "the egg that has enlightened us so much about the reproduction of animals through the observations of the immortally famed Malpighius"). Perhaps the original Dutch wording "door de waarneemingen van den onsterflijken Malpighius zoo veel ligt aan de voortteeling der dieren hebben bygezet" was difficult to understand. Tsuboi apparently thought that this part of the sentence was subordinate to the first part, but this is not the case. In Tsuboi's translation, which reads "it is very clear from the experiments of Malpighius that it possesses magical vital functions" (*kii no seiki o guyū suru koto, Malpighius no jikken ni yorite*

hanahada akiraka nari 奇異ノ生機ヲ具有スルコト「マルピギウス」ノ実験ニ由テ甚ダ明ナリ), Malpighi's observations are not connected with the achievements of embryology. The use of the term *seiki* 生機 (vital functions) is probably inspired by the use of *levens beginzel* (principle of life) in Boerhaave's original text. *Levens beginzel* is the term the Dutch translator uses for the term *stamen pulli* in the Latin language original of *Commentary on the Aphorisms*.⁷¹ Boerhaave is borrowing this term from Malpighi, who wrote in *De Formatione Pulli in Ovo*:

It is therefore proper to acknowledge that the first filaments of the chick pre-exist in the egg and have a deeper origin, exactly as [the embryo] in the eggs of plants.

Quare pulli stamina in ovo praeexistere, altioremq̄ue originem nacta esse fateri convenit, haud dispari ritu ac in plantarum ovis.⁷²

The mechanistic theorists, beginning with Boerhaave, interpreted the sense of “pre-exist” (praeexistere) in this description to mean that all parts of the body pre-exist in the embryo, and they used Malpighi's observations to prove it. The preformation theory held that during the development process the parts of the body did nothing more than simply grow; they were not taking form, because they already had form. The term *pulli stamina* (first filaments of the chick) in Malpighi's text certainly lends itself for such an interpretation. The Dutch translation *levens beginzel* is however a much more obscure term, a difficult term indeed for a Japanese scholar who lacked background knowledge of European mechanistic theories. Yet Tsuboi had the insight to offer a surprisingly accurate translation, rendering *levens beginzel* as *sūtai no genshi* 雛体ノ原始 (the origin of the chick's body) .

Observations of the yolk and albumen are contained in both of Malpighi's treatises on the formation of the chick in eggs, but as shown below, the explanation of the absorption of nourishment within the egg is based on the theory of Harvey, another embryologist who observed chicken eggs and was regarded as a leading authority at that time. In *Commentary on the Aphorisms*, Harvey's theory is cited as follows:

But the yolk, although it provides extremely good nutrition, requires a stronger constitution of the viscera, because, as Harvaeus following Aristotle has very well indicated, the chick uses in the first days after hatching out of the egg, the yolk, that is stored in its stomach, as its nourishment, but the albumen is consumed in that period of time, when the chick develops within the egg from a tiny invisible spot to a considerable large size, and therefore it is thought that the albumen is more capable of easily transforming into nutrition than the yolk (p. 60).⁷³

Tsuboi gives an accurate translation of this portion as well:

Although the yolk is excellent nutrition, compared to the albumen it is difficult to digest. The reason for this is very clear from the theory of Harvaeus (name of a person). According to that theory, on the day when the chick first breaks the shell, the yolk still remains in its stomach and feeds the body of the chick. While the chick is within

the shell, from the time that it is just a little spot until it breaks the shell, the chick uses the albumen as its nutrition. Therefore, the yolk is already inherent in the chick's body and is used after the various vessels and organs are fully established, and while the chick is still in the shell and the fibers are still extremely fragile and thin, it is nourished necessarily by the albumen. This is because the albumen is extremely easy to digest.⁷⁴

Harvey had reported on the chicken egg observations described in these quotations in “Chapter 36: The perfect hen's egg is of two colors” (Exercitatio 36 Ovum Gallinaceum perfectum, est bicolor) of his *Exercitationes de Generatione Animalium*. This chapter is an annotation, based on observation, of Aristotle's theory in *De Generatione Animalium* that dwells upon the question why eggs are composed of two elements, namely the yolk and the albumen.⁷⁵ Harvey discusses the nutritive quality of the yolk and the albumen in the following way:

When medical scholars affirm that the yolk is the hotter and more nutritious portion of the egg, this I imagine is meant as it affords food to us, not as it is found to supply the wants of the chick in ovo. This, indeed, is obvious from the history of the formation of the chick, by which the thin albumen is absorbed and used up sooner than the chick, as if it formed the more appropriate aliment, and were more readily transmuted into the substance of the embryo, of the chick that is to be. The yolk, therefore, appears to be a more distant or ultimate aliment than the albumen, the whole of which has been used up before any notable portion of the yolk is consumed. The yolk, indeed, is still found inclosed within the abdomen of the chick after its exclusion from the shell, as if it were destined to serve the new being instead of milk for its sustenance.⁷⁶

In a copy of *Manbyō chijun* that formerly belonged to the late Achiwa Gorō and is now kept in the Kyōu Shooku Library, I discovered a note in the margin that concerns the above theory of the yolk and begins with the phrase: *Seiken iwaku* 誠軒曰ク (according to Seiken). Seiken is one of the pen names (*gō* 号) of Tsuboi Shindō, and thus the annotator is informing the reader that the notation expresses Tsuboi's view. What the note says is this:

According to Seiken, “[the yolk] still remains in its stomach and feeds [the body of the chick]” means to gain nutrition by absorption through the absorption vessels. Moreover it is the same as the insects nourish their bodies with the fat in their bodies while hibernating. This is also absorbed through the absorption vessels. Therefore the fat is greatly reduced after hibernation.⁷⁷

Making an analogy between the yolk stored up in the stomach of chicks that have emerged from the egg and the fat stored up in the bodies of hibernating insects, the annotator lays special emphasis on the absorption vessels (*kyūshūkan* 吸尿管). Those vessels figure importantly in Boerhaave's physiological theory, although they are not mentioned in the passage of the *Commentary on the Aphorisms* to which *Manbyō chijun* here corresponds. Marginal notes by

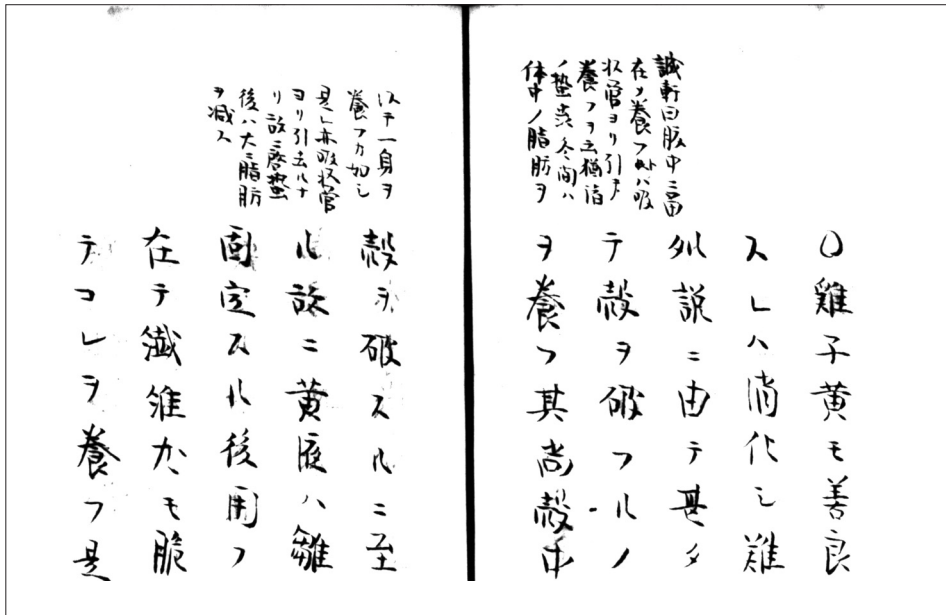


Figure 6. Note regarding the yolk, attributed to Tsuboi Shindō, in margin of Kyō Shooku Library copy of *Manbyō chijun*.

Tsuboi are very rare in the copies of *Manbyō chijun* that survive today, and the existence of this note is evidence that the discussion of the egg's nutritive qualities was of special interest to Tsuboi.

Conclusion

In this article, I have traced the trail of transmission of Western embryological observation records from its European origins to Japan, and I have examined the application of these records to physiological theories in Europe and Japan. My analysis reveals that the Western medical knowledge that was absorbed in Edo period Japan was not exclusively of a practical nature, as has often been claimed; highly specialized knowledge was transmitted also, together with the methodological and philosophical background of that knowledge.

The observational data gained by the new exact disciplines such as embryology that emerged in seventeenth-century Western Europe became the basis for Boerhaave's medical theories. The data were recorded and disseminated in the form of numerous quotations in *Commentary on the Aphorisms*, the vernacular Dutch version of a work first published in Latin. Tsuboi Shindō, the scholar of Dutch learning who took up the tremendous task of putting this voluminous work into Japanese, translated not only Boerhaave's medical theories, but also the many citations of the new disciplines that Boerhaave used to support his theories. Among them, I have focused on Malpighi's embryological observations of the formation of the chick in the egg, because these observations constituted the cornerstone of Boerhaave's

physiological ideas on the development of the body and the production of blood in the body, as well as his ideas on the first principle of life. Through the medium of Tsuboi's accurate translations, the Western scholarship represented by Boerhaave and Malpighi was transmitted to Edo-period Japanese students of medicine. This included a lot of rather sophisticated information about the formation of the heart and various blood vessels in the embryo at various stages of the developmental process; it was not merely practical learning for application by clinicians. The medical students and doctors who read Tsuboi's manuscript—and these were not few, for his private school was called upon by many, and we know of the existence of at least twelve copies of his translation, which circulated in manuscript form⁷⁸—got a clear exposition of the idea that an analogy could be made between birds and humans, and they learned that meticulous embryological observations of the formation of the chick in the egg had been enormously important in the development of Western physiological science.

Acknowledgments

I am deeply indebted to the following libraries.

Amsterdam University Library
 Antwerpen City Library
 International Research Center for Japanese Studies Library
 Kanazawa City Library
 Kyoto University Library
 The Medical Library, Kyoto University
 The Kyōu Library of the Takeda Foundation for the Promotion of Science
 Kyushu University Library
 National Diet Library
 Tenri Library
 Tohoku University Library
 Tokyo University Library
 Waseda University Library

To these libraries I express my sincere appreciation. I would also like to express my deep gratitude to Professor Matsuda Kiyoshi for his advice and guidance, and to Keiko Cryns for her support.

REFERENCES

- Adelmann 1966
 Howard B. Adelmann. *Marcello Malpighi and the Evolution of Embryology*. Cornell University Press, 1966.
- Adelmann 1975
 Howard B. Adelmann ed. *The Correspondence of Marcello Malpighi*. Cornell University

- Press, 1975.
- Aristotle 1990
Aristotle. *Generation of Animals*. Loeb Classical Library, Harvard University Press, 1990.
- Blankaart 1686
Steven Blankaart. *De Nieuw Hervormde Anatomie*. Amsterdam: Jan Ten Hoorn, 1686.
- Boerhaave 1709
Herman Boerhaave. *Aphorismi de Cognoscendis et Curandis Morbis*. Lugduni Batavorum: Johannem vander Linden, 1709.
- Edo Halma 1796
Halma-shi Oranda jisho 波兒馬氏和蘭辭書. Manuscript (attributed to Takano Chōei), collection of the Kyōu Shooku Library.
- Everard 1661
Anton Everard. *Novus et Genuinus Hominis Brutique Animalis Exortus*. Medioburgi: Ex Officina Francisci Kroock, 1661. University of Amsterdam Library.
- Fabricius 1621
Hieronymi Fabrici Ab Aquapendente. *De Formatione Ovi et Pulli*. Orig. pub. Patavii: ex Officina Aloysii Bencii Bibliopolae, 1621. Cornell University Press facsimile edition, 1967.
- Graaf 1672
Reinier De Graaf. *De Mulierum Organis Generationi Inservientibus Tractatus Novus*. Orig. pub. Lugduni Batavorum: Ex Officina Hackiana, 1672. Dutch Classics on History of Science, the Netherlands Society for the History of Medicine, Mathematics and Exact Sciences facsimile edition, 1965.
- Gunther 1930
Robert Gunther. *Early Science in Oxford*. Oxford University Press, 1930. 14 vols.
- Harvey 1651
William Harvey. *Exercitationes de Generatione Animalium*. Amstelodami: I. Ravesteynium, 1651.
- Hippocrates
Emile Littré. *Oeuvres complètes d'Hippocrate*. Paris: J. B. Bailliere, 1839-1861. 10 vols.
- Kegel-Brinkgreve 1983
Kegel-Brinkgreve and Luyendijk-Elshout. *Boerhaave's Orations*. Leiden: Brill, 1983.
- Kobayashi 1980
Kobayashi Yoshio 小林義雄. *Sekai no kenbikyō no rekishi* 世界の顕微鏡の歴史. Funabashi: Kobayashi Yoshio, 1980.
- Kulmus 1734
Johan Adam Kulmus. *Ontleedkundige Tafelen*. Amsterdam: de Jansoons van Waesberge, 1734.
- Littré 1839-1861

See Hippocrates.

Lower 1669

Richard Lower *Tractatus De Corde. Item De Motu & Colore Sanguinis et Chyli in eum Transitu*. Londini: John Redmayne, 1669. Oxford University Press facsimile edition, reprinted Dawson's of Pall Mall, 1968.

Malpighi 1673

Marcello Malpighi. *Dissertatio Epistolica de Formatione Pulli in Ovo*. Londini: Joannem Martyn, 1673.

Malpighi 1686

———. *Opera Omnia*. Londini: Robertum Scott & Georgium Wells, 1686.

Malpighi 1697

———. *Opera Posthuma*. Londini: Impensis A. & J. Churchill, 1697.

Morishima 1787

Morishima Chūryō 森島中良. *Kōmō zatsuwa* 紅毛雑話. Edo: Suharaya Ichibē and others, 1787.

Nagasaki Halma

Dōyaku Halma 道訳波爾馬. (Halma translation by Dō [Dō stands for Doeff].)

Tsuboi Shindō manuscript, Waseda University Library.

Ōtsuki 1822

Ōtsuki Gentaku 大槻玄沢. *Chōtei kaitai shinsho* 重訂解体新書. Kyoto: Katsumura Jiemon and others, 1826.

Palfyn 1718

Johan Palfyn. *Heelkonstige Ontleeding van 's Menschen Lighaam*. Leyden: Jan van der Deyster, 1718.

Saitō 1801

Saitō Hōsaku 斎藤方策. “Blankaart kaibō zusetu” 蒲朗加兒都解剖図説.

Manuscript ca. 1801.

Swieten 1742-1772

Gerard van Swieten. *Commentaria in Hermanni Boerhaave Aphorismos de Cognoscendis et Curandis Morbis*. 5 vols. Leyden: Johannem et Hermannum Verbeek, 1742-1772.

Swieten 1763-1776

———. *Verklaaring der Korte Stellingen van Herman Boerhaave, Over de Kennis en Geneezing der Ziektens*. Lugduni Batavorum: Joh. en Herm. Verbeek, 1763-1776. 4 vols.

Tsuboi 1826

Tsuboi Shindō 坪井信道. “Manbyō chijun” 万病治準. Manuscript completed in 1826.

Udagawa 1798

Udagawa Genshin 宇田川玄真. “Ensei Ihan” 遠西医範. Manuscript ca. 1798.

Udagawa 1805

———. *Ihan teikō* 医範提綱. Osaka: Kawachiya Tasuke and others, 1805.

Van der Korst 2003

J. K. van der Korst, *Een Dokter van Formaat. Gerard van Swieten, Lijfarts van Keizerin Maria Theresia*. Amsterdam: Bert Bakker, 2003.

Verheyen 1711

Philip Verheyen. *Anatomie oft Ontleed-kundige beschryvinge van het Menschen Lichaem*. Brussels: 't Serstevens, 1711.

Willis 1847

Robert Willis. *The Works of William Harvey*. London: Sydenham Society, 1847.

NOTES

¹ Van Swieten's work is a commentary on each of Boerhaave's aphorisms, giving detailed explanations, numerous quotations from classic and contemporary medical literature and many clinical examples. Van Swieten based the commentaries on his lecture notes of Boerhaave's classes. We can assume that they capture the essence of Boerhaave's doctrines faithfully, although van Swieten also inserted citations from articles in specialized journals such as the *Journal des sçavans* which were published after Boerhaave's death. A detailed study of van Swieten's commentary can be found in van der Korst 2003.

² For an overview of the main currents of embryological thought before Malpighi and Malpighi's contribution to embryology I am greatly indebted to Howard Adelman's research. See especially Adelman 1966, vol. 2. I have also used Adelman's English translations of Latin texts and titles.

³ Littré 1839-1861, vol. 7, p. 531. English translation Adelman 1966, vol. 2, pp. 733-734.

⁴ Adelman 1966, vol. 2, p. 734.

⁵ Harvey 1651, Praefatio. English translation Adelman 1966, vol. 2, p. 763.

⁶ Everard 1661, p. 45. English translation Adelman 1966, vol. 2, p. 765.

⁷ With respect to Malpighi's original text, I have relied on the copy of his *Opera Omnia* in the possession of the University of Amsterdam Library. See Malpighi 1686.

⁸ For a detailed explanation of Malpighi's microscopes, see Adelman 1966, vol. 2, pp. 828-832. For Malpighi's correspondence see Adelman 1975.

⁹ Adelman 1966, vol. 2, p. 831. See also Malpighi 1697, vol. 2, p. 26.

¹⁰ Malpighi 1686, *De Viscerum Structura*, Praefatio.

¹¹ Adelman 1966, vol. 2, p. 833. See also Malpighi 1686, *De Formatione Pulli in Ovo*, p. 10.

¹² In the embryological works of the time cicatrix (scar) was used in a variety of senses. In Malpighi's works it is thought to mean the blastodisk.

¹³ Adelman 1966, vol. 5, p. 2236. See also Malpighi 1697, vol. 1, p. 81.

¹⁴ With respect to the laboriousness of the effort by The Royal Society of England to reproduce Leeuwenhoek's observations with the compound microscope provided by Hook, see Gunther 1930, vol. 7, pp. 446-450.

¹⁵ Malpighi 1697, vol. 2, p. 31.

¹⁶ Adelman 1975, vol. 2, pp. 615-616.

¹⁷ *Ibid.*, vol. 2, pp. 620-621.

¹⁸ English translation: Adelman 1966, vol. 2, p. 955. Original Latin: Malpighi 1686, *De Formatione*

Pulli in Ovo, pp. 5-6. Difficilimum quidem est sensu ipso confirmare an sanguis prior sit exarato corde. Licet enim frequentissime fuscus et rubiginosus humor in exterioribus umbilicalium vasorum finibus appareat, nondum evidenter emergente corde, et speciosum videri possit cor fieri ex curvato et expanso vase, cui carnae portiones veluti manus exterius aptentur; quoniam tamen tunc temporis ita mucosa, candida, et lucida sunt omnia, ut sensus quocunque instrumento munitus nequeat distinctam partium compagem attingere, et, sicut in insectis videre est, ultimi senii partes in primordiis rudimenta habere, ita de corde adhuc mihi dubitandum superest. Hoc autem certo sensui patet sanguinem seu sanguineam materiam a primordiis non omnia illa habere, quae in ipso ex post deprehenduntur. Primo namque colliquamenti species a rivulis versus foetum deducti in vasis patet; mox vi fermentationis subvitellinus et rubiginosus emergit humor, qui tandem rubicundus evadit; sub postremis hisce naturis cordis ministerio in girum pellitur. Quare vereri possumus quod, sicut in sanguinea materia successivae mutationes, inducto colore, manifestantur, ita pariter cordis structura solo motu evidenter pateat, et quod quiescens adhuc praexistat, licet iners, nondum scilicet firmatis carnis fibris. Hoc vero certum videtur icorem seu exaratam materiam, quae postremo rubicunda efficitur, cordis motum antecedere, cor vero suo etiam motu sanguinis rubificationem.

¹⁹ Adelman 1966, vol. 2, p. 997. Original Latin: Malpighi 1686, *De Ovo Incubato Observationes Continens*, pp. 4-5. Unde adhuc coniecturam foveo, quam alias innui, succum, vasa, et cor forte praexistere et sensim manifestari, ut in arborum ovis observamus.

²⁰ Kegel-Brinkgreve 1983, pp.94-120.

²¹ De Graaf 1672, Ad lectorem.

²² Udagawa 1805, vol. 2, fo. 29 r-v. The original: 凡ソ気形ノ活物皆卵ヨリ生ゼザルハ無シ。唯其卵母体ニ在テ化スルト体外ニ在テ化スルトノ別アルノミ。所謂胎生ハ其卵母体ニ在テ化スルナリ。卵生ハ其卵体外ニ出テ化スルナリ。畜（タダ）ニ活物ノミナラズ、草木ノ子仁モ亦此レ一種ノ卵ニシテ。土中ニ在テ化スル者ナリ。

²³ I have investigated seventy-eight existing copies in thirty-one institutions and identified fifteen different editions spread over a span of sixty years. A detailed description of these editions is published in *Kagaku-igaku shiryō kenkyū* 科学医学資料研究31:3 (2003), pp. 299-300.

²⁴ Blankaart 1686, p. 485.

²⁵ *Ibid.*, p. 484. We zien in een hoender ei eer het gebroeit is, dat sig een lang lighaamtjen vertoont, 't welk na eenige uren broeyens een hoofje krygt, daar na ziet men aan het rugge-merg eenige knobbeltjes aan beide zyden; na een verloop van vier en twintig uren, siet men de hersentjes als blaasjes, met een gedeelte van het hert. Na twee dagen siet men het hertje kloppen, en krygt als verscheide sakjes, welke de twee holligheden met de oortjes syn. De hersenen werden ook styver, en de armen en beenen beginnen te komen, en dit geduurt zoo lange, tot alle de deelen in 't Vrugje sig vertoonen.

²⁶ Malpighi 1686, *De Formatione Pulli in Ovo*, p. 4. English translation: Adelman 1966, vol. 2, p. 951.

²⁷ *Ensei ihan* was a compilation of detailed translations of Blankaart's work on anatomy and selections from the works of Verheyen, Kulmus, and Palfyn.

²⁸ Saitō 1801, vol. 6, fo. 77 r-v. 吾鶏卵ヲ創破テ見ルコトアリ。始メ形スルニ長キ体ヲ顕シ、而シテ一少時ノ後小頭ヲ生スルヲ見ル。此後脊髓ノ両方ニ少ク結節ヲ顕ス。其後八時程過テ頭腦及ビ心ノ一部分ヲ加ヘテ見ユ。二日ノ後心ガ鼓動シ、種々ノ袋ヲ生ジ、心ノ両室及ビ両耳ヲ生ズ。而シテ腦モ破強^(ママ)ニナリ、手足始テ来ル。而シテ続テ其後漸々諸部調ヒ、全ク活気ヲ顕ス。

²⁹ In der daad, een volwassen mensch, die twee honderd pond weegt, is in zynen eersten oorsprong

verhoolen geweest in een dropeltje dartelende schuim, en uit zulk een klein lighaamtje is hy gegroeid tot zoo groote zwaarte.

³⁰ Die geheele vermeerdering in de vaste deelen is door de vogten aangebragt; dit leeren de waarneemingen van Malpighius in een gebroeid wordend ey genomen, die reeds van Hippocrates ondernomen zyn, [waar uit blykt] dat een kuike, reeds zoo sterke vaste deelen hebbende, van een onzichtbaar lighaamtje gegroeid is binnen een en twintig dagen door het verdunde vogt van het wit van het ey.

³¹ Malpighi 1686, *De Formatione Pulli in Ovo*, p. 2.

³² 今マ成年ノ人ノ身体ノ重量ヲ試ムルニ通ジテ二百「ポンド」ヲ以テ中トス。而ルニ其起源ヲ求ムレバ唯ター泡ノ揺精ノ中ニ隠在スル者ヨリ他無シ。此ノ如キ至微ノ物ヨリシテ、此ノ如キ至顕ノ凝体ヲ成スト雖ドモ、其由テ来ル所ヲ尋ヌレバ一モ極小ナル元実ノ血液ニ駕シテ日夜送輸セラレ来テ、漸ク相接續シテ成ル所ノ者ニ非ザルコト無シ。此ノ事「マルピギウス」(人名)曾テ牝鶏ノ卵ヲ伏スル[アタタムル]時ニ於テ実験スル所口甚ダ明ナリ。依ト加刺得私モ亦既ニコレヲ試験セリ。其書ニ云ク牝鶏ノ卵ヲ伏スル纔ニ三七日シテ孵[カイワル]シテ雛ト為ル。已ニ雛ト為ル時ハ凝体頗ブル強剛ナリ。是レ三七日間卵中些少ノ白液ノ溶解シテ化成スル所ノ者ヨリ外ナラザルナリ。(chapter 21)

³³ Maar dat vogt van het wit heeft door de samengestelde [*fabricata*] werktuigen van het kuiken nog verder moeten verdund en volmaakt worden, eer het door die vaatjes, welke door hunne kleinte alle begrip ontwyken, heeft konnen doorgaan.

³⁴ 然ドモ卵中ノ白液雛鶏ノ凝体ヲ為サントスル時ハ必ズ其体中ノ細管ヲ運行シテコレヲ化成セザルコトヲ得ズ。然ルニ其管極メテ細小ナルユヘニ稠凝ナル白液能ク其中ヲ流通スベキノ理無シ。故ニ其管中ヲ運行シ凝体ヲ化成セントスルノ前ヘ必ズ其雛鶏ノ体中ノ諸器ノ機能ニ由テ其質ヲ溶解稀釈ニセザル可カラザルナリ。(chapter 21)

³⁵ 造物の業はデスカルテスの説によれば器械術を以てするようになる物なり。

³⁶ Het menschelijk lighaam maakt voor zig zyn bloed uit eene stof, die geen bloed is. En het komt 'er niet op aan, of het menschelijk lighaam klein zy, en byna in het begin van zyn bestaan, of reeds volwasen en sterk zy; zoo onafscheidelyk is de tegenwoordigheid van bloed van de vastgestelde natuur van het menschelijk lighaam, dat het in het zwakste kind zoo wel is als in den sterksten man. Ja in eene menschelijke vrugt, zoo ras ze met de oogen kan gezien worden, is reeds rood bloed, en wel op dien tyd, wanneer nog in de moederkoek, nog in de vliezen van het menschelijk ey, nog in de vogt binnen deze vliezen bevat, eenig teken van rood bloed gezien wordt. Hieruit blykt, dat het menschelijk lighaam de maaker is van het bloed, zelfs in dat teer en slymig beginzel.

³⁷ 人身ノ機能ハ能ク血ニ非ザル者ヲ以テ血ト為ス。且ツ嬰童ト成人トヲ別タズ、至弱ト

至強トヲ論ゼズ、皆血ヲ有セザルハ無シ。之ニ加テ児胎ノ始テ母体ニ舍スル其初メ已ニ赤血ヲ具ス。然ルニ此時ニ於テハ胞衣胎膜及胞水ノ中猶絶エテ赤血ヲ見ルコト無シ。此ニ由テ、コレヲ觀ル時ハ、児胎ノ赤血ノ始メテ生ズル者ハ胎中ノ機關ニ由テ自ラ生ズル者ニシテ、母体ヨリ来ル者ニ非ズ。人身ノ血ヲ造クル者ハ即チ人身ニシテ、至脆至弱ノ児胎ト雖ドモ、亦能ク自家ノ機能ニ由テ赤血ヲ生ズルコト知ル可シ。(chapter 97)

³⁸ 児胎ノ赤血ノ始メテ生ズル者ハ胎中ノ機關ニ由テ自ラ生ズル者ニシテ、母体ヨリ来ル者ニ非ズ。

³⁹ Wanneer nu in het eerste beginzel van een mensch rood bloed begint voort te komen, kan door proeven niet gemakkelijk bepaald worden, maar de onsterfelijke Malpighius heeft die zaak in een te broejen legend ey bewezen.

⁴⁰ 児胎ノ最初已ニ赤血ヲ有スルコト甚ダ試ミ難キコトナリト雖ドモ、「マルピギウス」

(人名) 鶏卵ニ於テ明ニコレヲ徴セリ。(chapter 97)

⁴¹ Een bevrugt hoenderey, door geene broeying gestoofd, vertoont in zyne schaal, vliezen, wit, vrugtbe-ginzels [*Chalazae*], dojer, vliezig voedzel-zakje, [*Sacculus colliquamenti*] geen rood bloed altoos, schoon het met de beste vergrootglazen beschoud wordt.

⁴² For a detailed analysis of Malpighi's description of the early development of the unincubated blastoderm, see Adelman 1966, vol. 2, pp. 942-944.

⁴³ 鶏卵ノ未ダ嫗セザル者ヲ破リ看ル時ハ上好ナル顕微鏡ヲ施スト雖ドモ、絶ヘテ赤血ヲ見ルコト無シ。(chapter 97)

⁴⁴ Morishima 1787, vol. 3, fo. 15v-21v.

⁴⁵ Kulmus 1734, p. 2. Ōtsuki 1822, vol. 5, fo. 4r-5r.

⁴⁶ Kobayashi 1980, pp. 28-30.

⁴⁷ Alle uren byna zag men verandering in een te broejen leggend ey, en by den omtrek der legpaats van het voedzel-zakje [*cicatricula*] ontrent het dojer, vertoonden zig door de vergrootglazen reeds eenige zichtbare vaten; na weinige uren begonden de vaten onderscheiden te worden van de daarin bevatte vogten; ontrent de dertigste uur hadden deeze vaten eene groenagtige kouleur; ontrent de veertigste uur was 'er reeds eene yzerkouleur, (men noemt ze verdorde wyngaard kouleur, [*Xerampelinum*] omdat de verdorde wyngaardbladen in den herfst deeze kouleur hebben) tevens bleek het, dat de verzameling van alle deeze vaten by een liep tot één vat, welk zig uitstreckende naar de leg plaats van het voedzel-zakje, eindigde in zekeren boezem, die nu eerst gezien werd; welke boezem het regter oor van het hart was, gelijk daarna gebleken is; en in deezem boezem, afhangende van het gebogen lighaamtje [*Carina*] zag men duidelyk pols; en kort daarna een rood stipje in dat kloppend lighaamtje. Dat zelfde rood werd vervolgens gezien in het regter en linker hart, en in eene buis, in de langte van het gebogen lighaam loopende, welke de hart-slagader was.

⁴⁸ 其後牝鶏コレヲ嫗スルニ随テ一時一日内景漸ク変化ス。其初メ先ヅ「フートセルサツキ」(卵中ノ膜ノ名)ノ在ル所口黄液ノ周囲ニ於テ已ニ二個著シキ脈管顕微鏡ニ由テ見ユ。后少時ヲ経テコレヲ視ル時ハ、其脈管ト其管中保ツ所ノ液ト始メテ區別ス可シ。第十五時ニ及ブ比ホヒ右ノ管帯緑色ト為リ。第十四時ニシテ已ニ鉄色ト為ル(鉄色ハ一ニ枯蒲桃色ト言フ。蒲桃葉、秋ニ至テ此色ヲ為セバナリ)。其後右ノ諸管会シテ一管ト為ル。此管「フートセルサツキ」(見上)ノ処ヨリ起テ、一ノ稍々空潤ナル所ニ終ル。此空潤ノ処ハ即チ心ノ右耳ナリ。此物一ノ曲形ノ小体ニ懸垂セリ。其後幾バクモ無クシテ此心耳ノ中ニ於テ著シク脈動ヲ起コス。又少時ニシテ右ノ脈動有ル処ニ於テ一ノ赤点ヲ見ハス。又少時ニシテ心ノ左右ノ室中ニモ亦右ノ如キ赤点ヲ見ハス。此赤点一ノ曲形ノ物ノ中ニ長形ヲ為シテ、流出スル状ヲ為ス。此曲形ノ者ハ即チ動脈大幹ナリ。(chapter 97)

⁴⁹ *The New Shorter Oxford English Dictionary*, 1993, p. 401.

⁵⁰ Adelman 1966, vol. 2, pp. 939-940.

⁵¹ Udagawa 1805, vol. 2, fo. 27v.

⁵² “De vliesen *Chorion* en *Amnios* zyn mede al in het eitjen en maken met het Vrugjen een lighaam.” Blankaart 1686, p. 484.

⁵³ “Cor E pulsabat, recepto a venis humore rubiginosi et interdum xerampelini coloris.” Malpighi 1686, *De Formatione Pulli in Ovo*, p. 5.

⁵⁴ Adelman 1966, vol. 2, p. 956.

⁵⁵ For a detailed explanation of the term in Malpighi's works, see Adelman 1966, vol. 5, pp. 1087-1091.

⁵⁶ Tsuboi 1826b, chapter 97.

⁵⁷ Hieruit weet men, dat 'er uit eene niet roode stof rood bloed komen kan, en wel zonder vermenging van te vooren in weezen zynde rood bloed. Dat roode neemt zyn oorsprong in dat kloppend stijje, want het wordt eerst daar gezien, alwaar de klopping is, en 'er is reeds rood bloed, eer 'er eenige bloedige kouleur gezien wordt in de beginzels der lever van het kuiken: weshalven het gevoelen vervalt van de oude Geneesmeesters, die het werk der bloedmaaking aan de lever toeschreven.

⁵⁸ コレニ由テ観ル時ハ初メ赤色ナラザル者漸ク化シテ、赤血ト為ルコト昭々タリ。且ツ従前已ニ赤色ノ血此ニ混ゼズト雖ドモ、亦能ク自然ノ機能ニ由テ自ラコレヲ生ズルコトモ疑ハザル所ロナリ。故ニ赤血ノ起原ハ心ノ右耳ニ始マル。古人ノ所謂ユル血ハ肝ニ由テ生スト言フハ大ニ誤リナリ。(chapter 97)

⁵⁹ Malpighi 1686, *De Formatione Pulli in Ovo*, p. 5. English translation: Adelman 1966, vol. 2, pp. 953-955.

⁶⁰ *Ibid.*, p. 6.

⁶¹ Misschien doet hier ook iets toe de lucht, zonder welke geene plant, geen dier leeft, want na het agttiende uur der broeijing heeft Malpighius opgemerkt, dat de legplaats van het voedzel-zakje opklimt naar den stompen hoek van het ey, alwaar de lucht is. In volwassenen vloeit de chyl, die in bloed zal veranderd worden, aanstonds door de long, alwaar ze met eene zeer breede oppervlakte in zeer teere vaten byna aan de open lucht wordt blootgesteld. Naar het gevoelen van de oude Alchemisten was er een verborgen beginzel des levens in de lucht verholen.

⁶² Malpighi 1686, *De ovo incubato observationes continens*, p. 2.

⁶³ 凡ソ草木鳥獸蟲魚大氣ヲ失フ時ハ生育スルコト能ハズ。体中造血ノ機能モ必ズ大氣ノ助無クバアラザルナリ。「マルビギウス」(見上)曾テ鶏卵ノ媪スルコト已ニ八時ナル者ヲ破テ、コレヲ見ルニ「フートセルサツキー」(見上)卵ノ鈍頭ニ向テ上移セリ。鈍頭ハ卵ノ大氣ヲ含メル処ナリ。動物既ニ生下セル後、自ラ飲食スルニ至テハ胃腸ニテ生ズル所ノ乳糜静脈及ビ心ノ右室ニ由テ直ニ肺ニ達シ、肺ノ機能ヲ受ク。夫レ肺ニハ大氣絶ヘズ来往シ、且ツ肺ノ諸管ハ甚ダ婁薄ナルユエニ其中ヲ通ズル液宛モ大氣ニ曝露スルガ如シ。肺ノ造血ノ機能ヲ助クルコト知ル可シ。古人ノ説ニ由レバ氣中ニハ一種生命ノ起原ト為ル可キモノヲ隠蔽セリト云エリ。(chapter 97)

⁶⁴ Udagawa 1805, vol. 1, fo. 13v. 故ニ気管ヨリ吸入スルノ氣、最囊ニ充張スレバ、其氣ニ脈ノ細絡ニ透(トヲ)リテ血中ニ入ル。此ニ由テ血、能ク氣ヲ含デ活発稀渙シ自ラ流動ヲ為スナリ。

⁶⁵ Blankaart 1686, pp. 23-24.

⁶⁶ Maar ook in een volwassen mensch komt 'er op vry gelijke wyze bloed uit de gebruikte spyzen: want de melkvaten zuigen de chyl, in de darmen bereid, eveneens in, als de vaten van het dojer het wit inzogen, welk door de warmte der broeijing verdund is; al de chyl komt samen in ééne chylvoerder. Dus liepen ook in een kuiken alle deeze vaten tot één binnen het Lamvlies [*Amnion*]. Door de warmte der broeijing, de beweging der vogten door de vaten, de kragt van het hart, de samenspannende werking der lucht, kwam 'er in een kuiken, welk geen rood bloed hadt, rood bloed binnen agt en veertig uren: in een gezond volwassen mensch komt 'er uit de chyl bloed in den tyd van vier en twintig uren, gelijk de waarneemingen van Lower en Wales geleerd hebben: en tot de verandering van chyl in bloed loopen in een volwassen mensch samen de warmte van het lighaam, de werking van de vaten en het hart, de kragt der lucht in de long aangezet op de chyl, die met het bloed doervloeit: dat dit nu in korter tyd geschiedt in een volwassen mensch, dan in een groeiend kuiken, schynt te moeten toegeschreven worden aan de veel kragtiger werking der vaten op de daarin bevatte vogten, aan de ademhaling, en den overvloed van het te voren in wezen zynde rood bloed.

⁶⁷ 成人飲食シテ血ヲ生ズルハ、殆ンド卵中ニ血ヲ生ズルト同理ナリ。其故ハ其腸中ニテ

製スル所ノ乳糜ヲ乳糜脈ヨリ吸収シ血中ニ輸スルコト、猶鶏子白ノ軀セラレテ溶解セル者ヲ黄液ノ周囲ノ細管ヨリ吸収シ血ヲ化成スルガゴトシ。卵中ノ液ハコレヲ軀スル温煖ト液ノ管ニ由テ運動スルト心ノ機力ト大氣ノコレヲ助クルトニ由テ、二十四時ニシテ赤血ヲ化成ス。健康ノ成人ニ於テハ諸種ノ機能ニ由テ、十二時ニシテ乳糜化シテ赤血ト為ル。是レ成人ニ在テハ諸種ノ機能共ニ強健ニシテ、且ツ呼吸シ又從前体中既ニ赤血饒多ナルユエニ卵中ノ液ニ比スレバ赤血ヲ化成スルコト速カナルナリ。(chapter 97)

⁶⁸ It is noteworthy that in *Commentary on the Aphorisms*, Boerhaave cites Richard Lower (1631-90) in connection with the observation of chyle in the blood. Boerhaave's ideas on blood creation are close to those Lower proposed in his treatise *Tractatus de corde. Item de motu & colore sanguinis et chyli in eum transitu* (Discussion of the Heart. Including Essays on the Movement and Color of the Blood, and the Flow of Chyle to the Blood, 1669). Lower did anatomical research on the structure and movement of the heart and discussed blood creation as the mechanical result of the actions of the heart and various blood vessels, the mixture with air in the lungs and the body's heat, and the fermenting action of various fluids that aided digestion. Tsuboi omits mention of Lower's name, but transmits his theory accurately. See Lower 1669, especially pp. 193-220.

⁶⁹ Eyeren, die onder eene brosse schaal zoo veele wonderen verbergen, en door de waarneemingen van den onsterflijken Malpighius zoo veel ligt aan de voortteeling der dieren hebben bygezet, worden insgelijks tot dit gebruik gebezigd. Het wit van het Ey, in zeer veele eigenschappen met de weij van menschen bloed overeenkomende, bevat in zig eene stof, die door de warmte der broejing veranderd, het verborgen levens beginzel van een kuiken in het vliezig zakje, waarin het teere vrugtje met zyn eerste voedsel bevangen wordt, [*Sacculus Colliquamenti*] binnen een en twintig dagen tot zoo groot een lighaam doet aangroeijen, want het dojier wordt niet verteerd, het wit alleen schynt tot voedsel van het kuiken in het Ey te dienen.

⁷⁰ 鶏子ハ一片脆薄ナル皮殻ノ中ニ在リト雖ドモ、奇異ノ生機ヲ具有スルコト「マルピギウス」ノ実験ニ由テ甚ダ明ナリ。故ニ此症ニ用ヒテ勝功有ル事知ル可シ。鶏子白ハ人ノ血中ノ物乙ト同質ニシテ、其中母体ノ煦温ニ由テ活物ノ体ヲ化成ス可キ物質ヲ含蓄ス。雛体ノ原始其養液ト共ニ卵中ニ隠在シテ、二十一日ヲ経テ雛体全ク具リ。即チ孵【カイワル】ス養液トハ鶏子白ヲ謂フ。何者殻中ノ雛体長育スルニ随テ白液漸ク消尽スレバナリ。(chapter 28)

⁷¹ Swieten 1742-1772, vol. 1, p. 31

⁷² Malpighi 1686, *De Formatione Pulli in Ovo*, p. 2. English translation: Adelman 1966, vol.2, pp. 944-945.

⁷³ Maar het dojier, schoon het een zeer goed voedsel geeft, vereischt sterker gestel van ingewanden, want, gelijk Harvaeus na Aristoteles zeer wel heeft aangemerkt, het kuiken gebruikt de eerste dagen, nadat het is uitgekomen, de dojier binnen zyn buik besloten, tot zyn voedsel; maar het wit wordt in dien tyd verteerd, waarin het kuiken uit een onzichtbaar stipje in het ey tot een behoorlyke grootte groeit, en hierom schynt het lichter tot voedsel te konnen veranderd worden, dan de dojier.

⁷⁴ 鶏子黄モ善良ナル養物ナレドモ、鶏子白ニ比スレバ消化シ難シトス。其理ハルハエウス(人名)所説ニ由テ甚ダ明ナリ。其説ニ云ク鶏雛始メテ殻ヲ破ブルノ日黄液其腹中ニ留在シテ、雛体ヲ養フ。其尚殻中ニ在ル間ダハ一点ノ小形ヨリ殻ヲ破ブルニ至ルマデ白液ヲ以テ栄養セラル。故ニ黄液ハ雛体既ニ具ハリ、諸管諸器大ニ固定スル後用フル所ノ者ニシテ、鶏雛尚殻中ニ在テ纖維尤モ脆薄ナル間ダ必ズ白液ヲ以テコレヲ養フ。是レ白液ハ尤モ消化シ易ケレ^(ママ)ナリ。(chapter 28)

⁷⁵ Harvey refers in his footnotes to *De Gen. An.* l.3.c.1. (*De Generatione Animalium*, liber 3, capitulum 1.) Harvey 1651, p. 210. See Aristotle 1990, pp. 262-264.

⁷⁶ Harvey 1651, p. 202. I have based my English translation on Willis 1847, pp. 304-305, but have made some minor changes. Latin original: Quod Medici affirmant, vittelum esse partem ovi calidorem, & magis nutridam; id intelligendum cen co, quatenus nobis cibus est; non, quod pulli in ovo alimentum magis idoneum suppeditet. Idque constat ex historia fabricationis pulli: a quo, tenue albumen prius, quam craffum, absumitur. Quasi propius alimentum sit, & transmutatu facilius in substantiam futuri foetus. Ideoque vitellus videtur esse alimentum remotius, & posterius, quam albumen: quippe totum albumen prius absumitur, quam vitelli notabilis portio defecerit. Imo vero vitellus in pulli abdomine reperitur, postquam hic exclusus fuerit; tanquam novello pullo pro lacte, quo nutriatur, inserviat.

⁷⁷ 誠軒曰ク、腹中ニ留在シテ養フトハ吸収管ヨリ引テ養フヲ云フ。尚諸ノ蟄蟲、冬間ハ体中ノ脂肪ヲ以テ身ヲ養フガ如シ。是レ亦吸収管ヨリ引去ルナリ。故ニ啓蟄後ハ大ニ脂肪ヲ減ス。

⁷⁸ I have examined two copies of Tsuboi's work in the possession of the Kyōu Shooku Library (乾 6457 and 阿知波1296), two in the International Research Center for Japanese Studies library (宗田 990), two in Koishi Hideo's Kyūridō private library, two in the Kanazawa City Library (589 and B2 4-49/ソ/49), and one each in the Waseda University Library (8-C244), the Tohoku University Library (9,8,7210-7216), and the Kyushu University medical library (マ28). A prewar catalogue of books in the Tokyo University Library also mentions a copy, but this was lost due to war damage.

要旨

江戸後期における西洋発生学思想の受容
—マルピーギの受精卵観察と坪井信道—

フレデリック・クレインス

江戸後期にヘラルツ・ファン・スウィーテン (Gerard van Swieten, 1700-1772) 著『疾病の診断及び治療に関するヘルマン・ブールハーフェの箴言の解説』 *Verklaaring der korte stellingen van Herman Boerhaave*. 1763-1776. (以下『箴言解説』と称する) という理論的医学書が日本に輸入され、蘭学者坪井信道 (1795-1848) によって『万病治準』 (1826年成稿) の題名で抄訳されている。

ブールハーフェは当時の機械論者の成功に倣って、成立しつつあった新科学の成果を自らの病理学理論の中に積極的に取り込み、生理や病気の概念を単純な機械論的法則で説明しようとした。ブールハーフェが影響を受けた新科学の一つはマルピーギ Marcello Malpighi, 1628-1694 の発生学であった。『箴言解説』ではブールハーフェの理論を裏付けるためにマルピーギの受精卵観察記録がまとまった形で引用されている。

本稿では、マルピーギの発生学思想の伝達に焦点を合わせて、このような西欧で発展しはじめていた新科学の知識が部分的に江戸期日本に伝えられたことを論じる。

本稿は二節から成る。第一節ではマルピーギの受精卵観察を17世紀までのヨーロッパの発生学思想の中で位置づけ、ブールハーフェの医学理論との関係を明らかにする。さらに『万病治準』完成以前の江戸期日本における受精卵観察についての知識を追跡し、坪井信道の知識背景を明らかにする。第二節では第一節を踏まえて、『万病治準』におけるマルピーギの受精卵観察記録の翻訳を『箴言解説』の原文ならびにマルピーギの原著にもとづいて分析する。