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**Evolution of prey via anti-predatory  
adaptation**

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**Changes of Art from the retinal one to that serves the mind**

You might recall the image of a ceramic urinal when you hear the name of French-American artist, Marcel Duchamp (1887-1968). While he submitted a readymade urinal entitled "Fountain," signed with the pseudonym, to the exhibition by Society of Independent Artists in New York, 1917, the Society refused to include it in the

exhibition. Since then till today, his artistic activities including this one have been a focus of critical discussions among artists until “Fountain” was defined as a monument to the historical initiation of modern arts that serve the mind.



I think I saw the picture of “Fontaine” together with the name of the artist Duchamp for the first time of my life when I took a class in fine art at high school. In fact, I was embarrassed how I can evaluate the black-and-white readymade urinal as an art. I evaluated it in vain as an art work in a classical sense to please the eye, for example, in view of elaborate carving of Greek sculptures or refined skills in the paintings in High Renaissance, or on accurate depiction of light in its changing color qualities emphasized in Impressionism. I was too immature to understand the conceptual art at that age.

Now that I have started my career as a scientist, I try to take a look again at the Duchamp’s work “Fontaine.” I still see it merely as a ceramic urinal, signed with a pseudonym. However, I now recognize that the image of urinal entitled “Fontaine” asks me who I am, i. e., it evokes my emotions and perception to understand the mind of the artist who presented the readymade urinal as an art. Evaluation of the artwork does depend on how individual beholder would evaluate it with induced emotions controlled by the conceptual mind in a top-down way. Now I understand how revolutionary Duchamp was to have proposed that artwork should be the collaborative entity by the artist and beholder, so-called the beholder’s share.

## Scientific consideration on Art

On this occasion in discussing Duchamp issue, some thoughts came up to my mind. First, human beings are endowed with ability to express natural will commonly applicable to science and art, though the way of act differs in the two cases. Science is concerned with objectively understanding of natural phenomena, based on empirical evidence from observation, repeatability of which can successfully disclose natural principle as a scientific truth. Art, in contrast, is a way human beings can share their idea of imaginative or technical skill subjectively and emotionally between artist and beholders. Art in this case can include music, literature, dance, movie, photograph, comic, etc.

Needless to say about the rapid and big progress in science, the changes also go over the changes in social and cultural life today, in contrast to those in the medieval times in Europe where the fully armored soldiers acted in and out of stony castle, or the period of civil wars in Japan with the typically topknot-armored soldiers with sword. The spread in transport of spacecrafts between the Earth's surface and outer space, global building up of internet that enables people to communicate throughout the world, etc. all owe such research developments in basic science accompanied by those in technology. Regrettably, however, the global problem arisen by the greenhouse effects, the excessive use of plastics resulting in unruly spread of the disposal of wastes over the earth, etc. are also the results of the scientific progress.

With respect to the uprooted change in basic science, we should first mention about the heliocentric system proposed and established by Nicolaus Copernicus (1473~1543) and Galileo Galilei (1564~1642). We can easily imagine how seriously people, including scholars, initially responded against their proposed model of the universe that placed the Sun rather than the Earth at the center of the universe in the church sponsored era in Europe. Since then till today, people express the unprecedented paradigm shift by saying Copernican change.

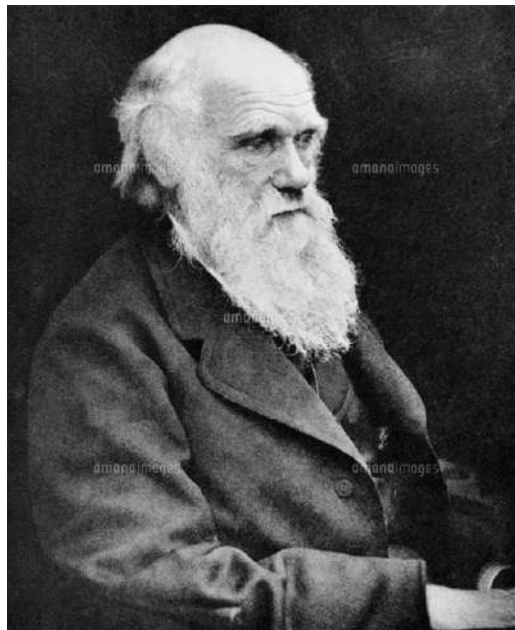
Sir Isaac Newton (1642~1727) is surely recognized as one of the most influential scientists with his proposal so-called Newtonian mechanics. His theory may have been more influential than that of heliocentrism. Who else could have thought of the quantification of invisible gravitational attraction between bodies? As the system of his theory on foundations of classical mechanics was so influential to the scientists in those days, they would have felt as if all problems in physics could be solved by his theory.

Newton's scientific viewpoint had been dominant until it was superseded by the theory of the relativity developed by Albert Einstein (1879-1955). Wave-particle duality is the concept in quantum mechanics that every particle or quantum entity may be partly described in terms not only of particles, but also of waves. The idea of wave-particle duality bore a minor resemblance to Newton's understanding of light, as Newton also made seminal contributions to optics. Since physicists then still had an attachment to Newton's theory and considered the idea of photons outlandish, they did not receive universal acceptance until the 1924 derivation of the Planck spectrum by S. N. Bose. Consequently, the nature of light as yet unsolved by classical physics was going to be explained by quantum mechanics in that objects have characteristics of both particles and waves (wave-particle duality) leading physicists into a new field. Thus, we call uprooted change such Copernican Revolution as "paradigm shift."

Now, let's turn our look at the paradigm shift on Art. In those days when Leonardo da Vinci (1452-1519) acted as a great polymath, many other artists were also active in scientific areas in Europe. Artists in that period incorporated the technique of one-point linear perspective, which an Italian architect Filippo Brunelleschi (1377-1446) is generally credited as the first person to have described it. By incorporating mathematically developed technique into their artworks, they were able to produce a three-dimensional vivid world on the two-dimensional space. After the transitional progress made in art during the long Renaissance period covering the span between the 14th and 17th centuries, a new move called impressionism arose initially represented by Claude Monet (1840-1925) with his historic painting, "Impression, Sunrise". Impressionism emphasizes accurate depiction of light in its changing qualities, including movement as a crucial element of human perception and unusual visual angles. Since then, Art in view of human culture continued to change in diverse directions including expressionism and symbolism brought by Paul Gauguin (1848-1903), and the movement of Cubism of the multi-perspective pioneered by Pablo Picasso (1881-1973) with a representative work *Les Femmes d'Alger (O. J. R. M.)*, and Duchamp who paved the way to conceptual art. Thus, modern art is still continuing to produce new cultural diversity. Now, how have you evaluated the historical progress in science and changes in art with respect to paradigm shift?

To discuss the progress in evolutionary biology, in which I am involved in my

research, it won't go without mentioning its founder Charles Darwin (1809~1882). He also brought a paradigm shift universally in biology. In his 1859 book *On the Origin of Species* he introduced the scientific theory that populations evolve over the course of generations by common descent into the diversity of "structure" (i.e., set of observable characteristics of an individual in color, morphology, and behavior). In another book he published later, he dared to include human descent from apes in his theory. As teased in caricatures of Darwin with a non-human ape body, the identification of evolutionism with Darwinism was accepted in an unthreatening way in public. Thus we now understand that forms of life are variable and accept Darwin's scientific discovery as unifying theory of the life sciences. One should remember, however, Darwin had hesitated to include the human descent from apes in his theory in *On the Origin of Species* under the social circumstance where many competing explanations prevailed in academic public at that time. Thus, paradigm shift is not established easily. Owing to Darwin we can view the world indeed as dwarfs standing on the shoulders of giants.



Charles Darwin

### **The theory of evolution in history of science**

The research in which I am involved with interest at present sits within the categories of Darwinism, i.e., I am so much interested in pursuing how the diversity of living organisms has been shaped by natural process over various ecosystems. This is

the most important proposition to be solved, I believe, in evolutionary biology. Though I hesitate somehow to describe my own research after I have introduced to you the gigantic legacy established by Newton or Einstein as above, but let me tell you and discuss my research now in progress.

A tremendous number of living organisms are propagating at present on the Earth, summing up to 8.7 million in terms of kind of species including those not yet registered. Indeed, you can easily feel sign of life everywhere around you. For example, when you extend your thoughts over the earth, birds and insects are chirping in the fields and mountains in Japan, so many animals and plants of strange features are seen in jungles, terrestrial mammals move around in African plains, colorful fishes in shoals are among the coral reefs, chemosynthetic bacteria and archaea around submarine hydrothermal vents form the food chain to support diverse organisms of yet unseen organisms of strange appearance, etc. Thus, it would be almost rare to find out space of no sign of life on this planet. However, so many questions still remain to be solved after 150 years since Darwin had appealed already in his books how these organisms had originated from and survived.

Among these questions, my research interest concerns about ecological systems with predator-prey interactions, asking how the system is involved with respect to the evolutionary aspect of prey. More specifically, predator could play a positive role in diversification of the prey. In the evolutionary biology today, researchers believe that the most crucial factor that organisms are forced to diverge into multiple structures and even generate new species could be scrambling for a limited amount of natural resources including foods among individuals.

Let me discuss this issue in more general social events. Suppose that two confectionary stores named A and B, respectively opened side by side. Obviously, a consequence will be that the two stores compete each other for taking limited numbers of costumers. To solve the completion, one consequence will be that either one of the two closes the store (local extinction) or change the sales goods so that the two stores no longer need to compete each other. This change of sales goods does correspond to adaptation of predator to live on different habitat (ecological niche) in evolutionary biology that could leads to the structural differentiation (character displacement) possibly to a new species in some cases.

As mentioned above, adaptation to a different natural resources (ecological niche) in evolutionary biology is a major working hypothesis popular among concerned researchers, i.e., ecological speciation is the evolutionary process by which populations evolve to become distinct species (ecological speciation/ecological theory of adaptive radiation).

I would emphasize, however, that competitive interaction among individuals occurs not only via resource competition, but also via predator–prey interactions in ecological dynamics. In fact, there is a theoretical study to support the major role of predator–prey interactions in evolutionary biology. And this theory is now becoming the focus of attention among researchers concerned. However, the above theoretical study has not yet proved positive. Consequently, it remains uncertain how strongly the predator–prey interactions affect on evolution. Some researchers suspect the other way around that predator suppresses the structural differentiation of the prey. Thus, we the human beings are still on the way towards the integral explanation on such a simple question about the mechanisms of evolution.

### **Research on malacological evolution**

Using groups of ground beetles (Carabinae) and respective land snail species in view of predator–prey ecosystem, I have been investigating their interaction by keeping alternative possibilities in mind “whether the predator could dump its prey species for another species or stick to the preys within the same species so that morphotype variants defensive to the predator would survive.” The latter would result in spread of phenotypic divergence and radiation of preys. Judging from the results of my observation, the coexistence of distinctive morphotypes of land snails with the normal morphotype in northeast Asia could support the latter possibility in terms of the role of predator for anti-predatory adaptations as a working hypothesis.



*Acoptolabrus gehinii* (right) and *Damaster (Carabus) blaptoides* (left), respectively, are in the family Carabidae, shown as a rear view. Both are natural enemy to land snails.



A Carabinae *Damaster blaptoides* preys on a land snail *Karftohelix (Ezohelix) gainesi*



When I started to address this issue, I recall that there were few papers published on the phylogenetic and ecological localities of land snails including *Karafutohelix (Ainohelix) editha* and *Karafutohelix (Ezohelix) gainesi* that inhabit specifically in Hokkaido island. So I had to investigate those subjects first to be established in order to obtain basic knowledge on which I could finally set up the working hypothesis. With respect to *Karafutohelix (Ezohelix) gainesi*, however, locality specific distribution of morphotype variants had been well established including molecular phylogenetic studies, as shown below.

In contrast, *Karafutohelix (Ezohelix) gainesi* seemed to have been poorly attracted for attention by concerned researchers. Accordingly, no papers had been published on its phylogenetic relationship among species. Besides the above two species of popular but distinct land snails in Hokkaido island, *Eulota chishimana* and *Paraegista takahidei* snails are also distinct in Hokkaido, but they both inhabit in peaceful coexistence locally. Since the latter two species differ apparently in morphology each other and some researchers have taken it granted that the two species are not within a genus. Therefore, no one may blame any researchers who were not careful enough to hit on an idea that the two are so closely related within a genus. In a way of thinking, I was lucky that I was able to carry out my research along my original idea toward materializing the working hypothesis without being interrupted by prejudice that might retard my way of thinking.



北海道におけるヒメマイマイ *Ainohelix editha* の地理的変異

First of all, we started a work by comparing DNA sequences between 5 species of the big-sized land snails including *Karaftohelix (Ainohelix) editha* and *Karaftohelix (Ezohelix) gainesi* inhabiting in Hokkaido island, using the nuclear internal spacer sequence and mitochondrial DNA as markers. The results were extraordinarily successful beyond expectation, i.e., the 5 species were shown to be phylogenetically so close despite they have distinct shell morphologies each other.



*Karaftohelix (Ezohelix) gainesi*



*Karaftohelix (Ezohelix) gainesi*

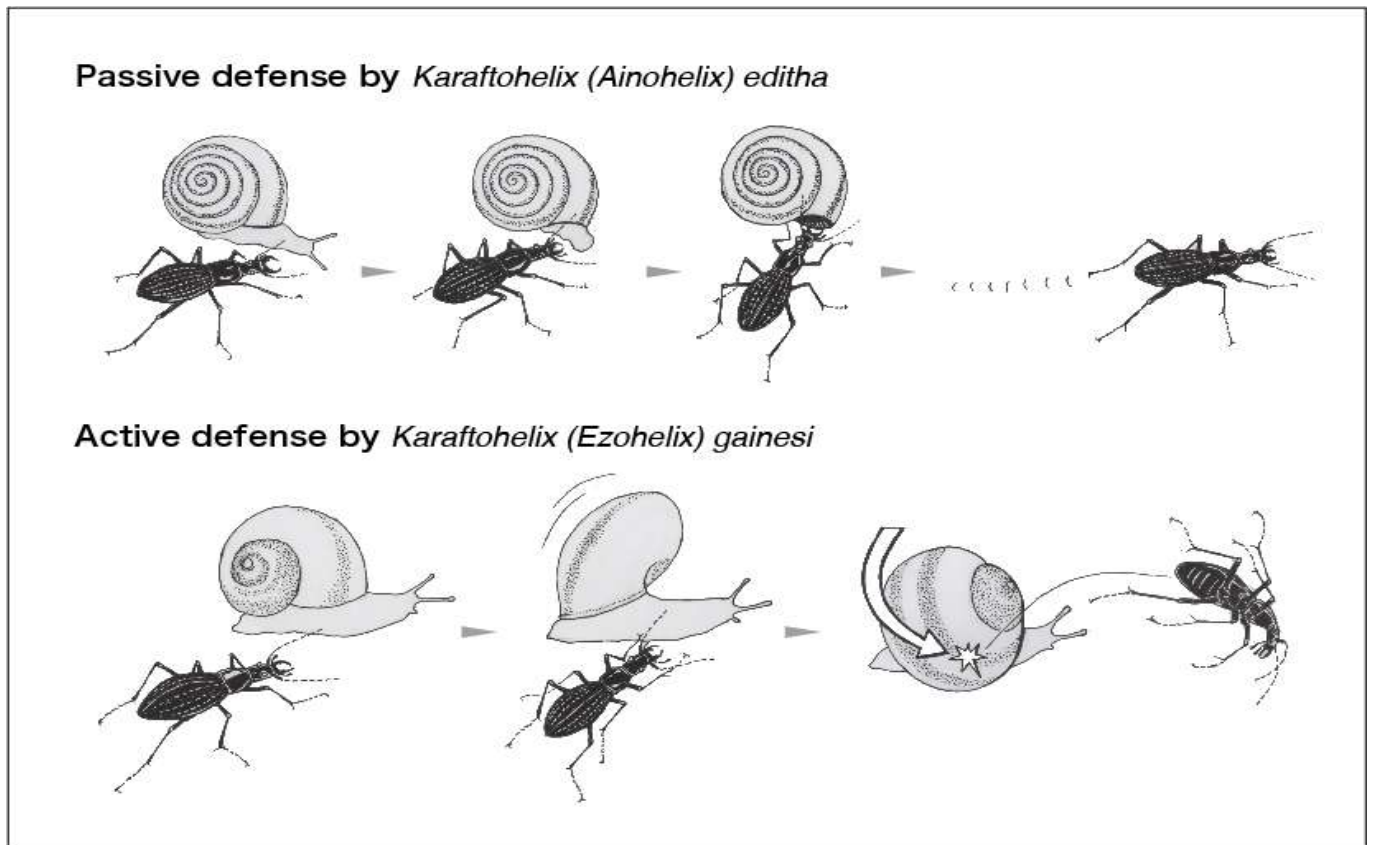
I should particularly emphasize that *A. editha* and *E. gainesi* showed a marked incongruence in the topology between nuclear and mitochondrial phylogenies, which could be most likely explained by historical introgressive hybridization between the two species despite the shell morphologies of the two species are quite distinct. The fact that the two species coexist locally, it implies that natural selection is able to maintain distinct morphologies in the face of gene flow (Morii *et al.*, 2015).

Finally, a most important discovery came up incidentally when I happened to observe a curious and peculiar behavior of a snail of *Karaftohelix (Ezohelix) gainesi* that I was raising.

The discovery came across when I happened to repeat teasing a moving *Karaftohelix (Ezohelix) gainesi* snail by picking a fight with a stick tip. The snail

responded to the pick by swinging the shell big around the body as if to counterattack the pick. In contrast, *Karaftohelix (Ainohelix) editha* responded to the pick by pulling the whole body inside the shell as snails of other species commonly do by instinct, as illustrated below. This discovery brought me an idea that the ground beetles (Carabinae) could have played an active role in the spread of *Karaftohelix (Ezohelix) gainesi* snails independent of *Karaftohelix (Ainohelix) editha* resulting in multiple ways of anti-predatory adaptation to predator attacks. In fact, both passive defense and active defense proved effective as anti-predatory action in the respective two species of land snails.

I should add that judging from the results obtained by our long-term field survey on the detailed comparison of the habitats between *Karaftohelix (Ainohelix) editha* and *Karaftohelix (Ezohelix) gainesi*, together with molecular phylogenetic analyses of several species of the subarctic northeast Asia land snails including these two species, we now suggest the spread of phenotypic divergence of northeast Asia land snails could be better explained by the results of predator-prey interactions rather than resource competition (Mori *et al.*, 2016; Mori and Wakabayashi, 2017).



Illustrated by Sota Hiraga

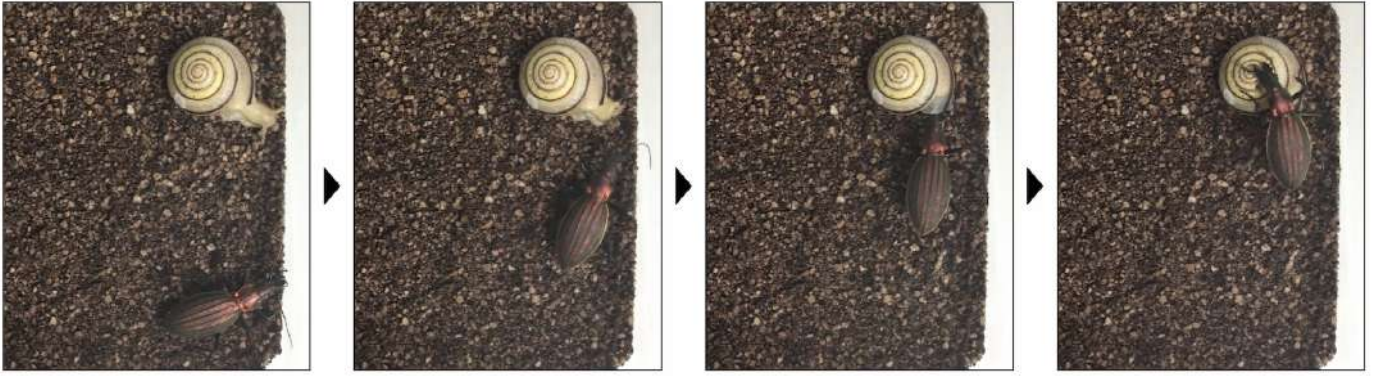
Description more in detail on the present article can be obtained at my personal web site <yutamorii.wordpress.com> and by the article I published in the 2016 issue of “academist Journal” (in Japanese). The active and passive defense behavior of land snails can be seen in YouTube shown at two web sites below.

Snail Hits Predator with Its Shell : National Geographic

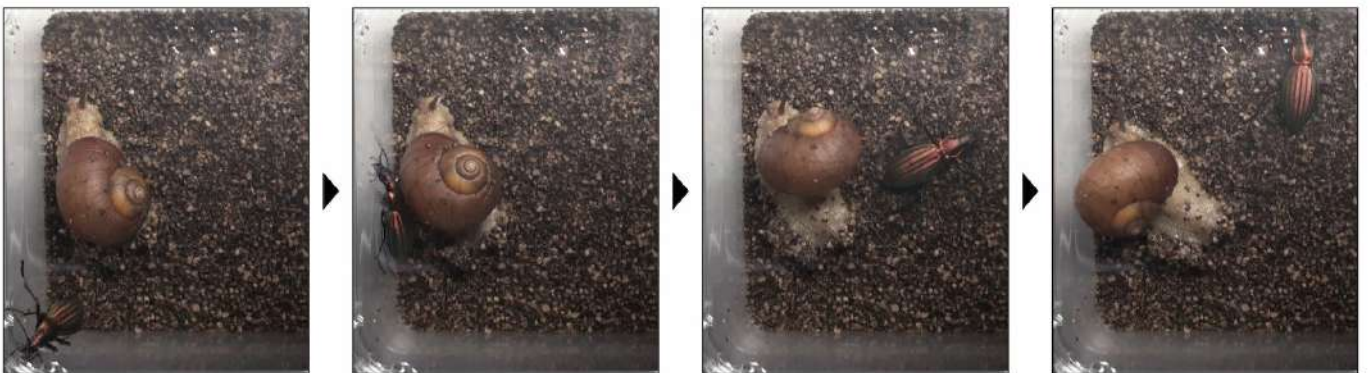
<https://www.youtube.com/watch?v=sgMnEDmx2sg>

Snails attack with their shells : SciNews

<https://www.youtube.com/watch?v=cWQtoxwNKLM>



“Passive defense” against the beetle *Acoptolabrus gehinii*  
in *Karaftohelix* (*Ainohelix*) *editha*



“Active defense” against the beetles *Acoptolabrus gehinii*  
in *Karaftohelix* (*Ezohelix*) *gainesi*

DNA sequence analysis on the land snails inhabiting in several local areas revealed that the active defense type snails generated independently from two separate lines of the passive defense type land snails, one found in Hokkaido island and the other in Far East Russian area, respectively (Morii *et al.*, 2016). We also suggested that introgressive hybridization between the passive defense and active defense type snails had occurred historically (Morii *et al.*, 2015).

## **Amusement aspect of terrestrial molluscs (land snails)**

The new finding I have made and described in this article was epoch-making in that the predator–interactions could play a more important role in promoting biodiversity rather than resource competition. It poses a new sight on the evolutionary biology, but at present is far below the level of paradigm shift made by Einstein or Darwin. No one can blame though that any researchers including me would devote themselves toward making an epoch-making contribution in the field of science.

Anyway, the picture of as yet unforeseen behavior of a snail counterattacking the predator beetle by swinging the shell big around the body became the center of public attention. Upon publication of our paper, interview requests flooded in from all over the domestic and oversea media summing up to over 160 including newspaper and the Web including highly evaluated academic ones like Nature, BBC News, and National Geographic. The sensational response by public may be obvious because such an active behavior of the snail to counteract against its enemy was totally unexpected as the general image people have for the snail was slow walking. I recall that I was somewhat confused when the topic was taken up in the amusement TV programs including NHK and other stations anchored or hosted, for example by Beat Takeshi, Matsuko Derakkusu, or Ariyoshi Hiroyuki, and furthermore in a TV program in Germany. Eventually, J. K. Rowling, best known for writing the Harry Potter fantasy series, shared the picture on Twitter. That was really an undeserved honor as I am one of her devotees. Looking back on those days in excited and pleasant uproars mentioned above, I realized again that scientific research has a side of ability to attract public interest of amusement, though it is a bit too late, to strengthen a similarity between science and art.

## Prospective significance of amusement

It has been a long time since popularization of the scientific and logic way of thinking on the daily matters among the common people was appealed. I am afraid however that the spread of the scientific thinking or the pleasure they get on resulting solution on the problem is slow and not satisfactory yet. Besides the research subject described above on the species diversification of the snail, I am involved at present in the joint research project with the general people (citizens) as a representative of the society called Science to the People Project, toward promotion of science literacy. The joint research project is a fieldwork on the large-sized great grey slug (*Limax maximus*) (about 15cm long) of invasive origin now spread in Japan (shown in the photo). We have been successfully able to discuss the results freely on a platform that we started up in 2014 entitled, Science to the People Project “Challenge to the slugs of invasive species” (<https://yutamorii.wordpress.com/science-to-the-people/>). (Morii *et al.*, 2016; Morii and Nakano, 2017; Morii *et al.*, 2018). Among those results, a report I published in ‘academist Journal’ in 2018 (in Japanese) entitled, “Activity of invasive slug *Limax maximus* in relation to climate conditions based on citizen's observations and novel regularization based statistical approaches” accompanied by a concerned original paper: Morii Y, Ohkubo Y & Watanabe S, 2018. Science of the Total Environment, 637-638: 1061-1068. doi:10.1016/j.scitotenv.2018.04.403, resulted in a tremendous proliferative spread on Twitter summing up to 700 thousand hits, generating problems connecting to the site at some moment.

<https://academist-cf.com/journal/?p=7702>



A large-sized great grey slug (*Limax maximus*)

In addition, I should mention that a grand prix 2019 was awarded to our activity of "Science to the People Project" by The Nature Conservation Society of Japan (Public Service Corporation). I certainly expect that our activity will help people to acquiring science literacy for themselves. Needless to say, scientific consideration on nature is a MUST lesson imposed on human beings to survive in harmony with other living organisms including plants and animals on this planet.

I wonder how the art literacy is taken under consideration. In my opinion, the art literacy has not heavily concerned compared with the science literacy in people's daily life in Japan as far as compared with public life in Nederland, Germany, and New Zealand, where I used to stay for some months to several years. For example, I happened to visit a public general hospital attached to the national university in Groningen where I stayed for 10 months in 2017-2018. Groningen is an ancient capital located in northern part of Netherland. The waiting room for the outpatients looked like a naturally well-lighted fancy big shopping mall in atrium style. There you can find pharmacy, coffee shop and restaurant, and a well arranged spacious hall with sofas, as the photo shows below. It gives an attractive atmosphere even for people otherwise not necessary to visit. It seemed to be paying as well. Such somehow artistic atmosphere make me to realize again that art to give a feeling of ease to patients' mind is so very important in parallel with advanced scientific therapy.





A view of hospital lobby in Groningen, Netherland

Now, how is the present situation of the hospital halls in Japan? The poorly lighted out-patient's hall or ward will be the general scene we will picture in our mind where we will see the mechanical reception windows and bulletin boards to announce the business-like matters; such atmosphere will rarely lighten the obviously depressed mind of people by seeing the art during waiting time in hospitals. We admit that Japanese tend to evaluate the efficacy of work rather than enjoying their free time in terms of

sense of values in everyday human life, although level of art itself is obviously so high. We now should consider on the social reforms to raise public consciousness so that people evaluate the art literacy and science literacy equally in their daily working. In addition, it should be most important that art literacy should spread into people regardless of classes in society as well as sophistication level of art.

(July, 2019)

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## Profile

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Yuta Morii Website : [yutamorii.wordpress.com](http://yutamorii.wordpress.com)

Science to the People Project : <https://yutamorii.wordpress.com/science-to-the-people/>



Field survey in Russian Far East (2014)



Field survey in Sakhalin (2012)



Field survey in New Zealand North Island (2018)



Field survey in Field survey in Kuromatsunai, Hokkaido (2016)

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