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建立后生动物标本老化特性的方法之一
ONE OF THE WAYS OF THE ESTABLISHMENT OF THE AGING PROPERTY IN METAZOA SPECIMEN

Makrushin Andrey Valentinivich
Doctor of Biological Sciences, Lead Research Officer
I.D. Papanin Institute of Biology of Inland Waters RAS
Aladin Nikolai Vasilievich
Doctor of Biological Sciences, Head Research Officer
Zoological Institute RAS
Vasiliev Aleksey Stanislavovich
Doctor of Biological Sciences, Lead Engineer
I.D. Papanin Institute of Biology of Inland Waters RAS

抽象。 本文基于模块化和单一后生动物的生存策略的比较。 在进化过程中发生的个体结构复杂化，降低了其细胞重新分化的能力。 因此，已经失去了个人的祖先特性，以防止其衰老并被大多数当前存在的后生动物无性繁殖。 这种损失是他们发展的转折点。 它加速了它的发展，从而提高了人们对环境变化的适应能力。

关键词：模块化动物适应性进化

Abstract. *The article is based on the comparison of the life strategy of modular and unitary Metazoa. The complication of the structure of an individual, which occurred in the course of evolution, reduced the ability of its cells to re-differentiate. Because of this, the ancestral properties of the individual to prevent aging and reproduce asexually by most of the currently existing Metazoa species have been lost. This loss is a turning point in their evolution. It accelerated it and thereby increased the adaptability of populations to environmental changes.*

Keywords: *modular animals, adaptability, evolution.*

In species close to the base of the evolutionary ladder of Metazoa, anti-aging processes take place in the body. These species are capable of asexual reproduction. The purpose of this article is to discuss how the rate of evolution and the adaptability of populations was influenced by the loss of potential immortality and the ability to reproduce asexually by most Metazoa.

In the course of evolution, the possibilities of preventing aging changes in the body have narrowed.

Metazoa are divided into modular and unitary. Modular are those that reproduce sexually and asexually, unitary - only sexually. With asexual, an individual is formed from a complex of somatic cells or from a part of the individual's body. A module of a modular animal is an individual formed by asexual reproduction, genetically identical to the parent. Modular animals are divided into two groups. In representatives of the first, the modules are not separated from the parent, but retain a physiological connection with it. These are sponges, hydroid and coral polyps, bryozoans, intra-powdery and colonial ascidians. In the representatives of the second group, the modules formed by asexual reproduction lead an independent life. Representatives of the second group are found among ctenophores, turbellaria, nemerteans, annelids, and echinoderms [5]. Some of these freely mobile invertebrates reproduce only sexually, that is, they are already unitary.

Any newly emerging system (of an organismic, supraorganic level, or multispecies) is at first simple. The number of functionally different elements in it is small and these elements are not very specialized. In the course of evolution, given the presence of underutilized energy resources in the environment and the possibility of their use, the number of functionally different elements in the system grows, the elements become more and more specialized, and the dependence of its parts on the whole increases. This allows the system to make better use of the resources of the environment. As power consumption increases, the energy flow through the system is increasing. Its power-to-weight ratio is also increasing. And the greater the power-to-weight ratio of the system, the more chances it has to survive in the struggle for existence and not be weeded out by natural selection [1, 8, 11].

The evolution of a Metazoa individual - is a special case of the evolution of biosystems. In an individual, in the course of evolution, the number of functionally different cells increased, the cells became more and more differentiated. This allowed it to make fuller use of the energy resources of the environment and, therefore, its power supply increased. An increase in the power-to-weight ratio gave an individual an advantage in the struggle for existence over less power-equipped individuals [2-4].

There is an assumption that the first Metazoa on Earth were sedentary and modular [6, 15, 16, etc.]. In modern sessile modular invertebrates, the number of functionally different cells in the body and their differentiation are the smallest in comparison with other animals. Only in them, due to the low differentiation of cells, derivatives of one germ layer can be converted into derivatives of another [5]. In freely mobile modular species, the number of functionally different cells in the body and their differentiation is greater. The number of functionally different cells in the body and their differentiation in unitary species are even greater. If the authors are right who believe that the first Metazoa on Earth were sedentary and modular, then the evolution of Metazoa is the transformation of the first sedentary modular species on Earth, first into freely movable modular, and then into unitary. At the same time, the differentiation of cells and the complexity of the structure of the individual grew, and its power-to-weight ratio became more and more.

In individuals of unitary species, ontogeny is irreversible. They die not only from external causes, but also from internal ones - from an endogenous decrease in homeostatic properties, that is, from aging. In contrast to the unitary species, the ontogeny is reversible in individuals of many modular species. They do not die of old age. Let us compare the ways in which sedentary and free-moving modular species avoid aging. They are most diverse in sessile modular invertebrates. Their individual is a colony. The first way they avoid senile changes is the transition to embryonic diapause. Adult modules dissolve during this transition, and the material of which they are composed serves to build diapausing somatic embryos. In sponges, they are called gemmules, in eaters - podocysts, in bryozoans - statoblasts, in intra-powdery and colonial ascidians - resting buds. Sponge gemmules are similar to morula, somatic diapausing embryos of other sessile modular invertebrates - with blastula or gastrula [5]. The formation of diapausing somatic embryos in sedentary modular species is the return of an individual to an embryonic state. The second way is reduction. Reduction leads to a decrease in the size of modules, death and/or dedifferentiation of all its differentiated cells. Upon reduction, the modules turn into reduction bodies similar in structure to early embryos [5]. Reduction is also the return of an individual to an embryonic state. The third way is to update the modular composition of the colony. The lifespan of modules in modular individuals is limited. One is replaced by another. Thanks to the update, the old modular specimen consists of young modules. The presence of these three methods of preventing aging in a sedentary modular individual makes it potentially immortal [12, 13, 17]. Some coral colonies are hundreds of thousands of years old [13].

Freely mobile modular invertebrates have fewer ways to avoid old age. They, unlike sedentary ones, age. Aging in them begins after several acts of asexual reproduction [5]. Some of them (turbellaria and nemerteans) can reversibly return to the embryonic state, but only by reduction [5]. They are not capable of forming diapausing somatic embryos. Thus, in the course of evolution, Metazoa showed a decrease in its ability to prevent senile changes in the body.

The decline in an individual's ability to prevent aging – is the result of natural selection.

The lower the cells of the body are differentiated, the more pronounced their ability to re-differentiate. In sedentary modular invertebrates (and only in them), as mentioned above, derivatives of one germ layer can be converted into derivatives of another. Their cells are the least differentiated among Metazoa. The formation of diapausing somatic embryos and reduction bodies, as well as embryos of new modules during the renewal of the modular composition of a sedentary modular individual, begins with cell dedifferentiation. In the course of its cells, specialization is lost. After this dedifferentiation, cells differentiate in new directions [5]. Consequently, the high ability of their cells to re-differentiate allows sedentary modular species to prevent the appearance of senile changes in the body. Freely movable modular species prevent the appearance of senile changes in the body (by means of reduction) also allows the ability to re-differentiate.

As a result of natural selection, the structure of the organism became more complicated, the number of functionally different cells in it, that is, their differentiation, increased, and the ability of cells to re-differentiate was weakened because of this. The decrease in the ability of cells to redifferentiate led to the fact that the individual's ability to prevent aging decreased. This led Metazoa to lose its ability to prevent aging, that is, to the emergence of unitary species.

The growth of differentiation of the cells of the body of an individual, which took place in the course of evolution, also led to the fact that its most highly differentiated cells, due to the loss of the ability to reproduce, became non-renewable. They also became non-renewable due to a decrease in the cells' ability to differentiate. Non-renewable cells play a key role in maintaining the body's homeostasis. But due to the second law of thermodynamics, sooner or later, but necessarily, they are destroyed. Their loss is senile involution. It reduces the homeostatic properties of the individual and its death becomes inevitable because of this decrease. Thus, aging is the result of not active suicide, as V.P. Skulachev [9, 10] proposes, but a passive consequence of the fact that the cells of an individual lack the ability to re-differentiate and therefore cannot compensate for the death of non-renewable cells by forming new ones instead.

From the above, it follows that only species that are close to the base of the Metazoa phylogenetic ladder do not age, and that all unitary species age. But it is widely believed that individuals of some unitary species are potentially immortal. So, V.P. Skulachev [9] writes that sea urchin, large crabs, pearl mussel, pike, shark, sea bass, toad, giant turtle, crocodile, raven, albatross, whale, naked mole rat and bat do not age. The reason for classifying these unitary animals as ageless is that they were not observed for a long time.

The loss of the ability to prevent senile changes in the body and reproduce asexually has accelerated evolution.

With asexual reproduction, a part of an individual's body gives rise to another or other individuals. In relation to a modular animal, sedentary and freely moving, the term "individual" (indivisible) is inapplicable. The term “geneta” is used instead. Geneta - is a collection of modules that have arisen from one zygote. It can be represented by one or many modular individuals [14]. All geneta modules are genetically identical to each other. Genetic diversity in populations of asexually modular species is therefore low. In the absence of sexual reproduction in the population, and in some populations this occurs [5]. A population may even consist of one geneta. The possibilities of natural selection (and the rate of evolution) are the higher, the greater the genetic diversity in the population.

Cell re-differentiation is necessary not only for the rejuvenation of the individual, but also for its asexual reproduction. Natural selection, aimed at complicating the individual, led to the loss of the cells' ability to re-differentiate, and in the individual - to the loss of the ability to reproduce asexually. Unitary species began to use a more efficient strategy of adaptation to the environment than their modular ancestors. Due to the loss of the ability for asexual reproduction, that is, for copying genotypes, the possibilities of selecting and screening out genotypes have increased. And this accelerated evolution and, consequently, increased the adaptability of the population. Its adaptability was also increased by the fact that, due to the loss in individuals of the ability to prevent senile changes, the change of genotypes accelerated in populations. The price of the increased adaptability of the population is the loss of potential immortality in individuals. But to maintain the reliability of the existence of a species, the ability of a population to reorganize genetically in response to changes in the environment with the help of natural selection is more useful than the potential immortality of individuals.

The acceleration of evolution, which occurred due to the loss of the ability to reproduce asexually, also accelerated the adaptive radiation of species. One of the reasons for the outbreak of species diversity that occurred shortly before the Cambrian may have been the loss of the ability of Metazoa to reproduce asexually at that time. Many Metazoa, which took the path of refusal to increase the differentiation of cells, did not die out, but survived and evolve. But they stand on the sidelines of the main path of development of life on Earth. Most of the species of the World Ocean, freshwater and land are unitary. The sharp prevalence of the number of unitary species over modular indicates that the emergence of unitarity is an aromorphosis, a progressive evolutionary change in the structure, leading to a general increase in the level of organization of the organism and an increase in its power-to-weight ratio. The emergence of unitarity in Metazoa is a turning point in evolution. Unitarity provided an evolutionary advantage in the struggle for existence in any environmental conditions, since it increased the adaptability of populations. A freely movable modular individual also has the property of aging. But after its death, there are descendants genetically identical to her, formed by asexual reproduction. The death of a freely mobile modular individual from old age does not accelerate the replacement of some genotypes with others, does not facilitate the genetic restructuring of the population to the changed environment and does not accelerate evolution.

The life strategy of plants is similar to the life strategy of sessile modular invertebrates [7]. Plant shoots are their modules. In plants, as in sessile modular invertebrates, somatic resting embryos - resting buds - serve to experience an unfavorable period for life. They are formed in trees and shrubs on the branches, in herbaceous plants - on rhizomes, roots, tubers. The bulb is a dormant bud. Resting plant buds and diapausing somatic embryos of sessile modular invertebrates are similar formations. The formation of dormant buds in plants is the return of the organism to the passed stage of development, its rejuvenation.

Plants can form dormant buds due to the high ability of cells to re-differentiate, and their cells have this ability because they are poorly differentiated. Due to the ability of cells to redifferentiate, plants also have the ability to reproduce asexually. Plants did not reach the critical stage discussed in the article during their evolution.

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