Biological Robustness and Biological Fragility

Biological robustness and biological fragility are widely studied in the field of biology today. ‘Robustness’ means the quality of being strong, and healthy or unlikely to break or fail, and ‘fragility’ means the quality of being easily damaged or broken. After reviewing relevant literature, I summarized the definition of biological robustness as a universal feature of organisms. Organisms can still maintain specific functions when disturbed externally and internally. Fragility and robustness represent the extremes of a continuum of possible responses to perturbations [1]. That is to say, fragility is also a universal feature of organisms, but when there is external or internal disturbance, organisms are prone to mutation or disease.

Biological robustness and fragility can also be divided into three levels of genetic material, individual organisms and ecosystems. Chromosomes are carriers of genetic material, and the number of chromosomes in each organism is constant. The continuous proliferation of somatic cells is accomplished by mitosis, which results in two new cells with the same number and shape of the chromosomes of the original somatic cells. In the germ cell, the number of chromosomes in the germ cell is reduced by half through meiosis. The fertilized egg after the combination of the two germ cells returns to twice of the number of chromosomes of the germ cells, leaving the number of chromosomes between the parents and the son relatively constant. At the same time, the central law of heredity and the principle of base complementation and pairing allow information from parents to be completely transmitted to son. However, genes will have spontaneous mutation rate, and under some physical or chemical action, there will be chromosome number and structure distortion, which is the biological fragility in genetic material.

At the individual level, biological robustness ensures that each new life is born as the same species as its parent, so that each species can continue to exist. And through the characteristics of biological fragility, the variation of species makes the species have a

new development direction. At the same time, for an ecosystem, biological robustness at this level usually refers to the ability of the ecosystem to regulate. But when pollution exceeds a certain limit, the ecosystem is prone to collapse, which means it is the fragility.

Nowadays, many scientists use experiments to study biological robustness and fragility. Rao described a robust experiment for Escherichia coli [2]. In the absence of a chemical gradient in the culture medium, Escherichia coli can be modeled as a random walk. Suppose you suddenly add a chemical uniformly to the culture, Escherichia coli senses an increase in the concentration of the chemical, the tumbling frequency drops sharply. However, when the cell finally realizes that there is actually no chemical gradient present, it gradually reverts to its steady state tumbling frequency.

A familiar example of fragility in daily life is AIDS. Its main pathogenesis is that under the direct and indirect action of HIV, the immune cell function is damaged and the immune system of the human body is destroyed, thus promoting the complications of various serious infections and tumors.

So why is biological robustness so important? First of all, only with robustness can organisms continue to survive normally when the environment does not change dramatically, so that species will not disappear immediately and ensure species diversity. Secondly, when an organism has favorable changes due to environmental changes, for example, the giraffe's neck becomes longer, the biological stability can continue to maintain this variation, and finally make the giraffe with a long neck can continue to survive.

Although beneficial variation in some species helps the survival of these species, fragility can also have adverse effects. When the living environment of an organism is changed very greatly, it will cause adverse changes in the organism. For example, people are often photographed by radiation irradiation, and it is easy to cause mutations in the cells in the body. The direction of these changes cannot be predicted in advance,

so we should avoid them. We can prevent organisms from living in environments with radiation at the source and reduce their chemical exposure.

References:

[1] Boukhibar, L. M. , & Barkoulas, M. . (2015). The developmental genetics of biological robustness. Annals of Botany, 117(5), 699.

[2] Rao, V. D. . Robustness in biological systems.