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Biological Robustness and Fragility

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1. Definition of Biological Robustness and Fragility

Biological robustness and fragility are two fundamental concepts in the study of the biological system.

Biological Robustness. The robustness of a biological system is the persistence of a certain characteristic or trait in a system under perturbations or conditions of uncertainty^[1]. This uncertainty could be from the ecosystem of the biological system itself or from disturbances caused by humans. In short, biological robustness is the ability of a biological system or individual to overcome or resist adverse conditions.

Biological Fragility. Fragility is another inherent characteristic of an ecosystem; it is related to the degree of change in species abundance and composition following disturbance^[2]. The sensitive response and self-recovery ability are two significant indexes for evaluating biological fragility.

2. Examples for the Biological Robustness and Fragility

Biological Robustness——Malignant Tumor

The malignant tumor is what we know as cancer. And tumor drug resistance is a major challenge in the current biomedical field. Cancer benefits from the robustness that allows it to resist the interference of internal and external factors such as the organism's immune system and drugs, thus maintaining the disease state^[3]. For example, the upregulation of genes such as MDR1 is known to directly mediate the phenomenon of tumor drug resistance, and the products of these genes are expressed to protect tumor cells against tumor drugs. Under tissue hypoxia, tumors can resist hypoxic perturbations by shifting from the tricarboxylic acid cycle to glycolysis and activating a feedback loop through HIF1 upregulation^[4]. The resistance to the effects of drugs and hypoxia indicates that the tumor contains a high degree of robustness.

Biological Fragility——Alpine Tundra Vegetation

Fragile ecosystems are characterized by high rates of species turnover or population volatility. Take China's Changbai Mountain Reserve as an example. Although rich in biological species resources and intact ecosystems, its special geology results in the fragility of lots of species. The ground is mostly composed of volcanic ash, the surface soil layer is thin and loose, and the climate is colder, with many windy days and a very short growing period for plants. Surface vegetation, especially alpine tundra vegetation, is extremely difficult to restore once it has been damaged. Only a small portion of the windfall area, which was hit by Typhoon 15 in 1986, has been restored to its original vegetation^[5]. This is a typical example of biological fragility.

3. Importance of Biological Robustness

Biological robustness plays a significant role in the adaption and survival of different biological communities. Species or systems with great biological robustness could withstand or recover from challenges that would otherwise be lethal^[6]. For example, crocodiles are recognized as living at the same time as the dinosaurs. But most creatures didn't survive the mass extinction event at the end of the Mesozoic 65 million years ago, including the great dinosaurs. An important reason for the survival of crocodiles to this day is their extreme biological robustness. Crocodiles choose a more static way of hunting compared to dinosaurs. Crocodiles can reduce their heart rate to a few beats per minute to ensure that they lurk underwater for longer and spend less energy to get food. Moreover, crocodiles have a very slow metabolism, and a well-fed crocodile can even hibernate for years. The crocodile survived to this day under its great biological robustness and adaptability to the environment in the face of the great perturbation of the dramatic climate change at that time. So biological robustness is an integral part of survival.

4. The Consequences of Fragility and How to Avoid it

The fragility may lead to the breakdown or extinction of a certain system or species. For example, corals are highly sensitive to the quality of seawater and the environment in which they live, and this vulnerability causes them to die very easily in situations such as seawater pollution. In many entertainment shows, there are male and female guests with makeup diving close to the coral or wearing lipstick kissing the dolphins in the aquarium, these actions will have a huge impact on these fragile creatures. And I think that biological fragility is an inherent characteristic of the

biological system itself and is very difficult to change. And what humans need to do is, first of all, government departments need to actively promote biological vulnerability protection and other contents, reduce industrial pollutant emissions, returning farmland to forest, and do a good job of ecological protection. Secondly, as citizens, we need to raise our self-awareness and travel green. With our joint efforts, the world will get better and better.

Reference

- [1] Stelling, Jörg; Sauer, Uwe; Szallasi, Zoltan; Doyle, Francis J.; Doyle, John (2004). "Robustness of Cellular Functions". *Cell*. 118 (6): 675 – 85.
- [2] Nilsson, Christer, and Gunnell Grelsson. "The Fragility of Ecosystems: A Review." *Journal of Applied Ecology*, vol. 32, no. 4, 1995, pp. 677 – 92. JSTOR, <https://doi.org/10.2307/2404808>. Accessed 25 Feb. 2023.
- [3] Sophie P, Jean-Loup R. Pierre B. Therole of domain redundancy in genetic robustness against null mutations. *J Mol Biol*, 2006,362:184~191
- [4] Kitano H. Cancer robustness: tumour tactics. *NaLure*, 2003, 426:125
- [5] Sun L, Wen Q Y. Ecological vulnerability and biodiversity of Changbai Mountain [J]. *Heilongjiang Science and Technology Information*.,2011,(4): 197
- [6] Kitano, Hiroaki. (2004). Biological Robustness. *Nature reviews. Genetics*. 5. 826-37. 10.1038/nrg1471.