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Ubiquitous Features of Biological Systems: Robustness and Fragility

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Biological robustness and fragility are two ubiquitous features of biological systems, important in understanding the ability of the systems to adapt an survive in their environment. Besides, they are two opposing concepts that refer to the ability of a biological system to maintain its functions and structures in the face of external or internal stressors. These two properties had been widely observed across many species. Hence, there is a significant amount research being conducted on biological robustness and fragility from the level of gene transcription to the level of systemic homeostasis[1]. Biological robustness and fragility plays

Biological robustness defines as a property that allows a system to maintain its functions against internal and external perturbations[1]. This fluctuations can include resistance to disease, tolerance to environmental changes, and the ability to recover from stress or injury. This enables them to thrive and reproduce, increasing their chances of survival. One example for biological robustness at molecular level is enzyme, which can function their ability efficiently over a wide range of temperatures and pH levels. It's wide known that enzymes are proteins that catalyze the chemical reactions in an organism and it usually have a specific optimal temperature and pH level at which they function most efficiently. However, in a certain wider range of these conditions, some enzyme can also maintain their ability in a different environment. Researches study on robustness based on the analyze of various data set, simulation and experimental techniques. The results plays an important role in large fields, such as biological system modelling and evolutionary biology[2].

Biological robustness is an integral part of survival for many organisms, as it allows them to adapt to changing environments and to maintain their normal functions. In addition, proteins, cells, biochemical networks, immune systems, organisms, and natural populations exist within changing and sometimes novel conditions under which the maintenance of satisfactory performance will determine persistence or function[2]. For example, the ability of polar bears to withstand extreme cold allows them to survive and reproduce in their harsh Arctic environment, ensuring the survival of their species. Moreover, some normal organisms can even live under more extreme environmental conditions. A study at MIT showed that mundane Earth microorganisms such as escherichia coli and yeast can survive, grow and replicate in 100% hydrogen. Due to the lack of oxygen, escherichia coli reproduction is halved and yeast reproduction is reduced to 40% of its usual rate[3].

On the other hand, biological fragility refers to the susceptibility and restoring capacity of an organism to external stressors. At the ecosystem level, biological fragility can be observed in the sensitivity of an ecosystem to disturbance or degradation due to factors such as climate change, pollution, or land-use changes. What most common happens around us is an ecosystem may be more vulnerable to the impacts of a natural disaster if it has already been degraded by human activities. For example, the removal of mangroves or other coastal vegetation can increase the vulnerability of coastal communities to storms and flooding.

The consequences of fragility can be severe, as it can lead to impaired function or even death. For

example, the sensitivity of coral reefs to changes in temperature and pH can lead to the destruction of entire ecosystems, with significant impacts on the marine life and the communities that depend on them. In humans, fragility can also have serious consequences, as it can lead to a greater susceptibility to diseases and other health problems.

There are several ways in which one can avoid fragility and promote robustness in biological systems. One approach is to improve the resilience of individual organisms, such as through selective breeding or genetic engineering. For example, breeding crops using recombinant DNA techniques that are more resistant to drought or pests can help to ensure their survival in challenging environments[4]. Another approach is to protect and preserve the environments in which biological systems exist, as this can help to reduce the impact of external stressors facing by endangered species. For example, establishment of climate change-ready marine protected areas (MPAs) in order to conserve the coral reefs[5], which can also help to preserve these ecosystems and the species that depend on them.

In conclusion, biological robustness refers to the ability of an organism to withstand external stressors and maintain its normal function, while biological fragility refers to the susceptibility of an organism to such stressors. Biological robustness is an integral part of survival for many organisms, and the consequences of fragility can be severe. Besides, There are several ways in which one can promote robustness and avoid fragility, including improving the resilience of individual organisms and protecting and preserving their environments. Insights into biological robustness and fragility is very important for humans in order to explore the mysteries of life and protect the environment.

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