

Biological Robustness and Fragility

In the biological world, robustness and fragility are two ubiquitous features that have a great impact on the survival and continuation of all species.

Among them, Biological robustness ensures that specific living functions are maintained despite external and internal perturbations. It is a result of different mechanisms working together, such as Gene expression, metabolic flux, biological development and mutation, they create the complex yet refined protection system to keep life going and keep races thriving.

For individuals, one of the most common examples of biological robustness is wound healing. When someone is injured, his/her body begins to repair and replace the devitalized tissues automatically. During the four phases of healing, each phase requires different organizations to cooperate and achieve a different purpose. The process begins with the hemostasis phase which activates the emergency system and blood clotting system to block the drainage. Next, in the defensive phase, neutrophils - a type of white blood cells enter the wound to destroy bacteria and remove debris, preventing the wound from infections. Then, in the proliferative phase, the wound is filled with tissues again. At last, during the maturation phase, the new tissue slowly gains strength and flexibility and the wound is cured. What's more, we could also find biological robustness in the whole specie. Genetic diversity caused by mutation plays an important role in evolution, helping the specie to adapt to the changing environment and keep to thrive. One of the most classical examples is the evolution of the peppered moth. Before the first industrial revolution, the dark-colored peppered moth was rare. However, their number increased drastically when people built factories and change the local environment. In the contrast, the light-color peppered moth, which was outnumbered before, was nowhere to be found, since its camouflage couldn't fit into the new environment anymore. These two examples perfectly explain that biological robustness is an integral part of survival. Without the self-healing process, the wound may become infected with bacteria and cause severe problems. If the peppered moth didn't mutate black-colored individuals, the whole specie would probably die out during the sudden change in their living environment. In a word, it is biological robustness that keeps individuals healthy and species thriving.

However, researchers have found that systems which have evolved to be robust against general perturbations are extremely fragile against certain types of rare perturbations. This led to the second topic of this essay - biological fragility. Although creatures on earth have evolved a relatively complete protection mechanism, there are always some crucial parts in the whole system that are fragile. Besides, the evolution of viruses and drastic changes in the environment could bring unpredictable harm to the defense system and cause a disaster for the whole specie. Take cancer as an example, in the year of 2019, there were 24 million people had been diagnosed with cancer and 10 million people passed away because of it. Cancer has existed for all of human history, but our bodies haven't evolved a cancer defense mechanism, nor did modern science find a way to get rid of it. Fortunately, scientists have discovered some of the main causes which could lead to these diseases through massive research and we already know that the majority of cancers, some 90-95% of cases, are due to genetic mutations from environmental and lifestyle factors. Exposure to carcinogens and tobacco could greatly increase the risk of having lung cancer. At this level, we could avoid fragility simply by developing a healthy lifestyle. However, sometimes the personal effort is not enough when the whole human race is facing challenges such as pollution and epidemic. Under these circumstances, we need to carefully consider all the possible outcomes and avoid fragility by developing a series of defensive measures.

In conclusion, we need biological robustness to help us maintain our health. However, we shouldn't only rely on robustness, finding fragile parts of our health system and finding ways to avoid the consequences of fragility is also an important part of biological science.

cite:

[1]. Kitano, H. Biological robustness. *Nat Rev Genet* **5**, 826–837 (2004).

[2]. John Maynard. How Wounds Heal: The 4 Main Phases of Wound Healing (2015.12.18)

[3]. Wikipedia. Peppered moth evolution

[4]. Wikipedia. Cancer