**Biological Robustness and Fragility**

Biological robustness and fragility are two important concepts in biology. To better understanding these two, I will do some interpretation.

Before defining biological robustness, knowing the meaning of robustness is basic. Robustness is the property of controlling system to maintain some other performance under certain parameter perturbation such as structure and size. Depending on the different definitions of performance, it can be divided into stability robustness and performance robustness. A fixed controller designed with the robustness of a closed-loop system as its objective is called a robust controller. Above all, it can be seen that robustness is the ability of the system to survive abnormal and dangerous conditions. So, it can see that biological robustness refers to the property that a biological system maintains its structure and function stability when it is disturbed by uncertain factors such as external disturbance or internal parameter perturbation. It is one of the overall properties of a biological system. This is a brief definition of biological robustness. While, biological fragility is the opposite side of biological robustness. First, I will talk about what is fragility. The fragility of health is one of the most fundamental flaws in humanity, and medicine aims to fix it. No matter how healthy we may currently be, future illness and disease are unavoidably a possibility for us, and any existing ailment serves to act as a reminder of the myriad flaws that are part of the human condition. Healthy persons may take preventative measures, such as numerous tests and screenings, in an effort to safeguard the fragility of their health. These efforts to protect oneself against the start of biological fragility, however, might be harmful since they increase uncertainty rather than reduce it. These are the embodiment of fragility in human beings. The same argument can be used for biology. Fragility is the superimposed result of sensitivity and self-resilience. Biological fragility is the ability to respond sensitively to biological disturbances and to recover themselves is an inherent attribute of the ecosystem.

Last paragraph I have given short definitions of biological robustness and fragility. From the definitions, it can see that these two properties are necessary for biology, especially biological robustness, which is integral part of survival. In the nature, an organism is always in a changing environment, but it can maintain a relatively stable internal environment, so that it can survive in a variety of environments. Therefore, biological robustness is best reflected in the adaptation of organisms to the environment. Biological robustness is a systematic property that can be observed, such as in bacterial chemotaxis [1], biological development [2], gene networks [3], etc. Biological robustness also exists in the occurrence, development and treatment of diseases, such as cancer treatment, metabolic syndrome treatment and so on. From these examples, biological robustness almost exists in everywhere in biological system.

There are many examples about them. I will talk about one for each other. In the biological robustness, bacterial chemotaxis is a kind of directional movement of bacteria, which is a basic attribute of bacteria to adapt to environmental changes and survive.[1] It enables bacteria to find food sources and escape toxic environment, which has a competitive advantage in survival. This process is achieved through a closed-loop feedback loop. During this period, there are changes in concentration between the enzymes produced and promote demethylation. Especially in the case of sudden changes in ligand concentration, the average activation level measured by frequency rapidly converges to a stable value. Therefore, no matter what the absolute value of the concentration is, the system can always sense and control its movement towards a region with a high concentration of the inducer, as long as it does not saturate its sensory system. And for biological fragility, the most obvious example is the biological fragility of tropical rainforests. The soil in the rain forest is poor, and the nutrients are almost all stored in the plants on the ground. Therefore, the above-ground vegetation becomes the most important and crucial part of the rain forest system, which is also the part most vulnerable to human destruction. Once the rain forest vegetation is destroyed, the nutrients will be quickly lost under strong leaching, and it is difficult for the surface plants to recover, and the whole ecosystem will collapse.

[1] Barkai N, Leibler S. Robustness in simple biochemical networks. Nature, 1997,387:913~917

[2] Nijhout HF. The nature of robustness in development. BioEssays, 2002,24:553~563

[3] von Dassow G, Meir E, Munro EM, Odell GM. The segment polarity network is a robust developmental module. Nature, 2000,406:188~192