Biological Robustness and Fragility

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Biological systems are the most sophisticated self-organizing systems in the world. Controlled by various of mechanisms, organisms could maintain their lives while perturbations from external and internal environment throughout the long evolutionary process. There is also common that sometime systems may performance unusual when being disturbed by the environment. Those phenomenons lead two important concepts, biological robustness and fragility. In the following context, I will give a discussion around these two concepts on their definition, importance, consequence and potential avoiding methods.

1 Biological Robustness and its Significance

Biological robustness is a kind of ability the systems gain during the evolutionary process to maintain systems' specific functionalities against external and internal perturbations. More specific, the robustness makes complex biological systems living against environmental and genetic perturbations. It doesn't mean that systems stay unchanged when the change of the environment happens. In contrast, the structure and components of the systems may keep in a flexible state[1] in order to maintain the key functions and adapt to the changes. As a complex dynamic systems, we could seem biological robustness as an ability to keep in a steady state (attractor). When perturbations appear, the robustness of the system would adapt to the change and stay at current state or transit it to a new attractor forced by the perturbation.

There are many biological activities which are the manifestations of the robustness. Take the cell division that occurs all the time in cellular organisms as an example. Due to the continuous mitosis of cells, DNA which in the single strand is likely to undergo base change and lead to the gene mutations. This may lead to the change of codon and then lead the change of transcription results. The transcription process may terminate even earlier than usual, resulting in the generation of wrong peptide chain. That may threaten the relevant functions of the systems. Suppression is a kind of mechanism to respond to such situation. A second mutation would occur in the mutated gene to correct the protein error or codon error caused by the first gene mutation. This situation is one of the multiple manifestations of biological robustness. In fact, robustness exist from the level of molecule to the level of whole system.

Robustness is vital for organisms to survive in the changing environment. In its definition, perturbation is emphasized as the background and the maintenance of key functions is the criterion when we talk about robustness. From the perspective of evo-

lution, the ultimate goal of the activities and evolution is to survive for living things. By using different mechanisms like positive or negative feedback, alternative and modularity in the various of situations, biological robustness meets their need. From the perspective of the system, robustness can make the system always find a stable state.

2 Biological Fragility and its Consequences

Biological fragility is a characteristic corresponding to robustness. When system meets unexpected disturbance and introducing control circuit may cause serious fault, the biological fragility could thus be shown. For example, immune system in human body is a kind of robustness and HIV mainly attacks the T cells in immune system. However, the greater the immune response of the virus, the greater the damage of HIV to the body. Thus, robustness could not maintain the immune function and so that the biological fragility manifest itself.

My understanding is that fragility is relative with robustness. In another word, the trade-off of the biological system leads robustness and fragility at the same time. The traits which are benefit to survival in perturbation know as robustness and others could be fragility. Thus, in most of time the consequences of fragility is diseases[2] in living things. From the system perspective, fragility leads unsteadiness and failures of the system. Biological fragility is usually abnormal, so it is difficult to detect them intuitive. If we consider the relativity of robustness and fragility, we could find potential fragility at the opposite side of robustness and provide preventive measures. Providing protection measures in advance for the opposite side of the conditions that robustness could tolerate may provide a method for fragility some extent.

References

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