Biological Robustness and Fragility

I first learned about the concept of robustness in a computer class, which is the ability of computer system or software to withstand or overcome adverse conditions. And it is also ubiquitous and indispensable feature of biological systems. So similarly, biological robustness refers to a characteristic that a biological system can maintain the stability of its function when it is disturbed by some external or internal uncertain factors. Organisms are always in a changing environment, but they can maintain a relatively stable internal environment so that they can survive in various conditions. And biological fragility refers to the susceptibility of biological systems to these factors, which represents that living organisms will be frequently perturbed by a wide range of factors. So, precisely because of the fragility of organisms, the importance of robustness is highlighted.

About biological robustness, I would consider bacterial chemotaxis to be a category of biological robustness. It actually refers to a kind of directional movement of bacteria, which is a basic property of survival in adapting to environmental changes. It enables bacteria to find food sources and escape from toxic environments, and has a competitive advantage in survival. Bacteria can adapt to changes in chemical inducers in a wide range of concentrations, and always adjust their behavior according to changes in the concentration of chemical inducers. The chemotactic ligand binds to the specific receptor MCP to form a stable complex composed of proteins Che A and Che W, Che A is a phosphorylation regulator enzyme, Che Y binds to the flagellar motor and changes, and the ligand bound to the receptor is corrected by Che A kinase, and the receptor is also reversibly methylated, methylation drives enzyme activates and adapts to changes in ligand concentration. During the adaptive process of the two proteins, one is Che R methylation, the other is Che B demethylation, and the feedback mechanism of Che B indirect phosphorylation promotes demethylation. This feedback mechanism, which can adapt to changes in ligand concentration, has been demonstrated through experiments and simulations. Especially with sudden changes in ligand concentration, the average activation level measured by frequency quickly converges to a stable value.

This means that the system only depends on the sharp change of ligand concentration to determine its frequency, but it is not sensitive to the absolute value of ligand concentration. Therefore, no matter what the absolute value of the concentration is, as long as the sensory system is not saturated, the system can always sense and control itself to move to the area of high concentration inducer.

As for biological fragility, in a paper on hermatypic corals in a certain see area in China, it was mentioned that the high fragility of some corals is related to poor seabed geology and seawater environment and excessive human activities have also exacerbated the degree of fragility. Some corals in a low fragility state are in relatively benign sea areas with less human activities. Some corals in a very low fragility state have higher coral coverage, species number, species diversity index and evenness in their living areas.

As I mentioned above, biological robustness is integral for every creature. The analysis and evaluation of biological fragility is conductive to judging the living status of biological system and taking corresponding measures.

As I mentioned above, biological robustness is integral for every biological system. Because it is obvious that biological systems must be robust against series of environmental and genetic perturbations in order to evolve. And robustness precisely represents this characteristic of biological systems. Without robustness, it signifies that the biological systems lose the ability to maintain when disturbed, and the system cannot continue to maintain its specific function in a flexible manner, which will be devastating to the biological system.

The biological fragility can affect and harm living organisms. I would like to divide this effect into internal part and external part. Internally, organisms need to have corresponding protective measures, so that organisms can still maintain essential functions when they are affected by adverse factors. Externally, organisms are supposed to find a suitable environment for survival, but also have a strong ability to adapt to different and complex environment.