Biological Robustness and Fragility

Feiyang Huang

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Biological robustness refers to the ability that allows a system to continue functioning despite external and internal perturbation, and it is regarded as a critical feature of complex, evolvable systems. This can include changes in temperature, pH, toxins or parasites. A biologically robust system can endure these changes without being seriously influenced and revert to its regular functioning once the perturbation has gone. The human body has numerous systems to maintain homeostasis or a stable internal environment to deal with external changes. For example, the body has mechanisms to regulate body temperature, blood pressure, and pH to ensure that these variables stay within a narrow range conducive to normal functioning.

Biological robustness is integral to survival because it allows organisms to maintain their functions while adapting to environmental changes, which is vital to survive and reproduce in the constantly changing world. Robustness is also considered an essential factor in the evolution of complex systems. Robustness-enhancing features are frequently selected by evolution because they allow an organism to tolerate environmental shocks and increase its chances of survival and reproduction. This interlinks the properties of robustness and evolvability, with robustness facilitating the evolution of complex dynamic systems.

Biological fragility refers to the susceptibility of a biological system to changes or perturbations in its environment. A biologically fragile system may be easily impacted by environmental changes, resulting in issues recovering to their regular functioning even after the perturbation has gone. The bleaching of coral is a specific example of fragility. Carbon dioxide reacts with seawater to form a weak acid, which increases the acidity of seawater, and the change in PH can easily make corals bleach. In addition, seawater temperatures as little as 1-2 degrees Celsius above the normal local seasonal maximum temperature can also trigger bleaching. Severe, long-time or repeated bleaching can lead to coral colony death, weakening coral resilience.

Biological fragility can have significant consequences for the fitness or survival of an individual organism. For example, if an organism is biologically fragile, it may have a reduced ability to produce offspring due to its inability to withstand environmental changes, resulting in reduced reproductive success. Biological fragility also has effects at the population level. If a large proportion of individuals in a population are biologically fragile, the population size may decrease over time due to a reduced reproduction rate or increased mortality. This can occur if the fragile individuals are less likely to reproduce or their offspring are less likely to survive due to their fragility. Then the decrease in population size can have several consequences for the ecosystem, including changes in the balance of predator and prey populations, disruptions in nutrient cycling, and reduced biodiversity.

One way to avoid the fragility of an organism is to protect it from environmental stressors. This can be achieved through measures such as habitat conservation or habitat restoration, which can help reduce stressors' impact on sensitive species. For example, suppose a species is susceptible to pollution. In that case, conservation efforts might focus on reducing the amount of pollution in its habitat or creating buffer zones around sensitive areas to protect them from pollution. Another way is to increase its diversity. A diverse ecosystem is more resistant to perturbations, as a diverse community of species can help buffer against stressors' harmful effects on individual species. This can be achieved through conservation efforts that focus on protecting and restoring habitats, as well as through efforts to promote the natural migration and dispersal of species.

It is also important to note that there is a trade-off between robustness and fragility, which refers to the balance between the ability of a system to maintain its functions and structure despite changes or perturbations in its environment and its susceptibility to these changes and the negative impacts they may have. In other words, a more robust system may withstand a greater range of perturbations without being significantly affected, but this may come at the cost of increased resource demands or reduced performance in other areas.

References

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