

A Brief Introduction on Biological Robustness and Fragility

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The biological robustness is a characteristic for a biological system to stay unchanged under disturbances or uncertain conditions¹. Depending on the type of disturbance involved, robustness can usually be categorized as mutational, environmental, recombinational, or behavioral robustness². Robustness is achieved by combining many genetic and molecular mechanisms and can progress by direct or indirect selection.

One example for biological robustness is the behavior of tumor cells when encountering some certain kinds of chemical reagent. The researchers have found that tumor cells that activate the expression of the multidrug-resistance 1 (MDR1) gene can resist the influence of drugs by exporting them out with the assistance of an ATP-dependent efflux pump³, which means that these tumor cells have the feature of environmental robustness as they can stay mostly unchanged under the impact of drugs.

There is no doubt that biological robustness plays a vital role in the survival. As a common feature for biological systems, robustness ensures the stability of these systems. On the one hand, the existence of robustness makes it possible for organisms to function under various conditions with little change in phenotype or fitness. Considering that most plants cannot move during lifetime, this feature can help them to adapt to large changes in temperature, water availability, salinity or food availability, which significantly increases their potential of survival. The importance of biological robustness can also be observed in proteins as they can tolerate many different kinds of solvents, ion concentrations or temperatures and maintain the shape thanks to this incredible characteristic. On the other hand, the biological robustness is also crucial in the process of biology growth and development⁴, which helps the organism's phenotype remain constant and survive. To be more specific, mutation can result in many different types of change in sequences and can prevent the gene from functioning properly or completely and sometimes even cause death. While the mutational robustness can make the phenotype stay unchanged to some extent and therefore maintain the normal function of the organism.

The biological fragility is a characteristic for a biological system to get affected or being destroyed under certain conditions. The biological robustness and fragility are interrelated instead of complete opposite concepts. For example, it has been found that complex biological systems are usually robust under common conditions but can be extremely fragile against certain types of rare perturbations⁵. As fragility can do harm to organism largely, it is also very important to have more understanding and research

on this concept.

The example of tumor cells can also prove the fragility of biological systems. As it has been stated above, tumor cells are usually robust under the effect of traditional chemical drug, which explains why similar strategies will fail in some cases. However, the researchers found that tumor cells are extremely fragile when they simultaneously disrupt two or three key intersections critical to tumor growth and progression through system biology approaches in a biochemical network⁶, which may lead to new strategies that can be used treat cancer in the future.

Consequences of fragility include weakening and even death of organisms, which might be really harmful. Thus, it is meaningful to find some tragedies to avoid fragility to benefit our health. First of all, avoiding being affected by some environmental factors like artificial radiation and ultraviolet light, which may cause fragility by increasing the rate of gene mutation. Secondly, eating healthily are beneficial for strengthening robustness and weakening fragility as it can make immune system and body stronger. So, it is crucial to quit smoking and eat green vegetables in our daily life. Lastly, don't change the residence too frequently as factors like temperature, water quality and illumination can all have an influence on biological system and lead to fragility.

It's clear that both biological robustness and fragility are general characteristics in biological systems. The definitions of these factors are quite different as the former refer to a characteristic for a biological system to stay unchanged under disturbances or uncertain conditions whereas the latter refer to a characteristic for a biological system to get affected or being destroyed under certain conditions. But the two concepts are closely correlated with each other. And by finding more methods to avoid fragility and strengthen robustness, we can better protect our health and solve many biological puzzles.

References

- (1) Kitano, H. Biological Robustness. *Nat. Rev. Genet.* **2004**, 5 (11), 826–837.
- (2) Fernandez-Leon, J. A. Evolving Cognitive-Behavioural Dependencies in Situated Agents for Behavioural Robustness. *Biosystems* **2011**, 106 (2), 94–110.
- (3) Kitano, H. Cancer as a Robust System: Implications for Anticancer Therapy. *Nat. Rev. Cancer* **2004**, 4 (3), 227–235.
- (4) Lagha, M.; Bothma, J. P.; Levine, M. Mechanisms of Transcriptional Precision in Animal Development. *Trends Genet.* **2012**, 28 (8), 409–416.
- (5) Kwon, Y.-K.; Cho, K.-H. Quantitative Analysis of Robustness and Fragility in Biological Networks Based on Feedback Dynamics. *Bioinformatics* **2008**, 24 (7), 987–994.
- (6) Bianconi, F.; Baldelli, E.; Luovini, V.; Petricoin, E. F.; Crinò, L.; Valigi, P.

Conditional Robustness Analysis for Fragility Discovery and Target Identification in Biochemical Networks and in Cancer Systems Biology. *BMC Syst. Biol.* **2015**, 9 (1), 70.