BIOLOGICAL ROBUSTNESS AND FRAGILITY

Today, a growing number of scientists are concentrating on biological robustness and fragility, a topic that has many applications in many different domains, including systems biology, medicine, and genetics. Robustness is a trait that maintains internal and external stability despite perturbations, as opposed to fragility, which is its by-product(Kitano, 2004). Understanding biological robustness and fragility can aid in building models of organisms, give a theoretical foundation for systems biology(Kitano, 2007), and help to better understand specific disorders and develop more effective treatment alternatives(Kitano, 2004). This essay discusses the definition and importance of biological robustness and explores the consequences of fragility and available treatments.

From gene transcription to the wellbeing and evolution of complex living systems, biological robustness is a property that may preserve system function through perturbations. A nice illustration of monitoring a system that maintains robustness through feedback regulation is bacterial chemotaxis. E. coli has both run and tumble motility at different chemical concentration gradients, which is achieved by a signaling system mediated by receptors attached to the flagellum(Yi et al., 2007). This enables it to perceive environmental perturbations well and to avoid danger. Additionally, the robustness of the cell cycle, hormone regulation, signal transduction, and other modules required for the development of higher living systems can be seen. As a result, it is clear that robustness is crucial for living organisms, both to maintain their normal functions and to withstand internal and external disturbances. More importantly, however, robustness is linked to evolution. For complex living organisms to evolve, they must possess robustness, and phenotypic plasticity is one type of robustness that can be adaptable to outside disturbances(Kitano, 2004). Robustness guarantees the system's proper operation. And the system displays fragility when it is unable to resume its regular operation following a perturbation.

Robustness and fragility are frequently trade-offs in systems, and when a system exhibits fragility, it is so vulnerable that it can no longer maintain normal function(Kitano, 2004). According to research (Kaizu et al., 2010), CDC14 overexpression in the budding yeast cell cycle causes cell death as a result of an imbalance in the dose of CDC14 and ESP1, which results in extremely fragile cell cycles. Fragility poses a severe threat to human health and life because it is harmful not just at the cellular level but can also lead to various human disorders including diabetes, cancer, HIV, and others. Consequently, it is crucial to comprehend and steer clear of biological fragility.

Due to numerous concepts, there are several approaches to avoid fragility, such as increasing the original system's robustness or identifying the intruder's fragility and disabling it. Evolvable systems show vulnerability to exceptional perturbations but are resilient to typical disturbances (Carlson & Doyle, 2000). In addition to addressing the problem of medication resistance, this could aid in the treatment of cancer. If the robustness and mathematical theory could be merged, the analysis of the treatment alternatives would be improved. Despite the large number of mathematical models that can currently be used for analysis, there is still no precise theoretical framework that can be used to model system perturbations.

In conclusion, this essay goes into further detail about what biological robustness and fragility are, as well as the impacts of fragility and how to avoid them. It is discovered that robustness is a biologically evolved trait that may be seen at several system levels and is able to maintain system functioning in the face of perturbations. Contrarily, fragility leads to improper system operation and a number of human disorders. By realizing how fragile the system is, people may be able to fight off some diseases. Therefore, it is crucial to comprehend robustness and fragility. Medical and systems science will advance and additional cures for diseases like cancer and HIV will be made available by putting these theories to use in various fields.

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