BIOLOGICAL ROBUSTNESS AND FRAGILITY

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Biological systems are complex, dynamic, and subject to a wide range of environmental stresses and perturbations. As a result, they must be capable of maintaining their functionality and adapting to changing conditions in order to survive. Biological robustness and fragility are two related concepts that describe the ability of organisms and systems to maintain their function and resist perturbations, or conversely, their vulnerability to disruption and failure.

Biological robustness is the capacity of an organism or system to continue operating normally and to withstand disturbances or damage under a variety of circumstances. At different levels of biological structure, from the molecular and cellular level to the organismal and ecosystem level, robustness can be seen. For instance, robustness at the molecular level can be used to describe proteins' capacity to continue functioning in the face of changes in temperature, pH, or other environmental conditions. Robustness can be used to describe an animal's capacity to maintain internal balance while fending off illness, harm, or other difficulties at the organismal level.

The immune system, which is in charge of defending the body against pathogens and other dangers, is one instance of biological robustness. The immune system is able to identify and react to a variety of infections, and it may adjust to new challenges through processes like immunological memory and antigenic variation. Its resilience enables the immune system to effectively defend the body against a variety of infectious agents as well as new threats like developing viruses or antibiotic-resistant bacteria.

Contrarily, biological fragility refers to an organism's or system's susceptibility to disruption and failure as a result of external pressures or disturbances. A wide range of factors, including genetic and environmental ones, irregularities in development, and exposure to chemicals or other stressors, can contribute to fragility. For instance, certain genetic abnormalities can make a person more prone to illnesses like cancer or Alzheimer's disease and more vulnerable to environmental stresses.

Coral reefs, which are susceptible to a variety of environmental pressures such as ocean acidification, pollution, overfishing, and climate change, are one example of biological fragility. These pressures have the potential to upset the ecosystem's delicate balance, causing coral bleaching, disease outbreaks, and biodiversity reductions. Coral reef fragility emphasizes the significance of comprehending and minimizing environmental conditions that can cause ecological collapse.

Because it enables organisms and systems to sustain their function and resist disturbances in a changing and unpredictable environment, biological robustness is essential to survival. Many mechanisms, including as redundancy, feedback control, and plasticity, can lead to robustness. These mechanisms allow biological systems

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to continue operating normally despite a variety of environmental difficulties, such as temperature changes and pathogen exposure.

Contrarily, fragility can have negative effects on ecosystems and living things. In the face of environmental pressures, fragile systems are more prone to disturbance and failure. They may also be less able to adjust to shifting circumstances or repair damage. For instance, ecosystems that have gone through significant environmental disturbances like oil spills or deforestation may be less able to withstand stressors in the future and may see a reduction in biodiversity or production.

In conclusion, biological robustness and fragility are two sides of the same coin. Robustness protects against external stressors, whereas fragility shows how susceptible biological systems are to perturbation. For an organism to survive and serve as a foundation for adaptation and evolution, it must be able to sustain robustness, recognizing the causes of biological brittleness and creating mitigation solutions.

References

[1] Text revised by ChatGPT, developed by OpenAI (https://openai.com/) accessed on 02/27/2023.