Report for question 1

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Robustness and fragility are two properties that are prevalent in the biology. Robustness and fragility may sound like two opposing concepts, but they do co-exist in the biological world and are interrelated.

Robustness is a property that allows a system to maintain its functions despite external and internal perturbations. One essential characteristic of complex systems that can evolve is robustness. For complex biological systems to evolve, they must be resistant to genetic and environmental changes. Evolution frequently chooses features that might increase the organism's robustness. [1]

Robustness exists in different aspects of biology, from the micro to the macro level. At the micro level, for example, blood glucose regulation in the human body maintains stable blood glucose levels: when blood glucose levels rise to high levels (e.g. after eating), blood glucose acts directly on the pancreatic islets, causing an increase in the release of insulin from the beta cells therein, which in turn leads to a decrease in blood glucose levels; as blood glucose levels fall, the secretion of insulin decreases. As blood glucose levels fall to lower levels, the alpha cells of the pancreas secrete glucagon, which promotes the breakdown of liver glycogen and fat, thereby increasing blood glucose levels, while an increase in blood glucose levels reduces the secretion of alpha cells. This is a form of robustness based on a negative feedback mechanism. Robustness can also be seen in the stability of gastric acid pH in humans and the maintenance of a constant body temperature in thermoregulated animals. At the macro level, robustness can be seen in the regulation of population size.

Biological robustness is essential for the survival of organisms. Organisms have upper and lower limits of tolerance to each ecological factor, and the more tolerant an organism is, the more robust it is to that ecological factor, and therefore the more it can survive changes in that ecological factor. We know that changes in the living environment are a constant, and that robustness can help organisms maintain their structural and functional stability in these changing conditions. We can extend this to all ecological factors. The more robust an organism is to all ecological factors, the better it will survive and the more widespread and abundant it will be in nature. Conversely, organisms with poor robustness will have difficulty adapting to changes in ecological factors and will therefore not survive in nature.

Fragility is a property that refer a system unable to maintain its functions when facing external and internal perturbations. Fragility can lead to damage to the structure and function of an organism, as well as the death of an individual organism or even the extinction of a species. An example of fragility is cancer, the number one enemy threatening human survival. When a mutation occurs in a cell's proto-oncogene or oncogene, the expression of normal genes is altered and the cell undergoes frantic, uncontrolled cell division, which in turn develops into a population of cancer cells capable of invading surrounding tissues and organs, destroying the infested organ and ultimately leading to the death of the individual.

There are different approaches we can take to avoid biological fragility. In agriculture and animal husbandry, we can use selective breeding, cross breeding, and gene editing to avoid certain pests and diseases. For example, promising uses of CRISPR tools in agriculture have already been shown in crop plants such as wheat, corn, and tomato. SDN-1 in wheat is being used to provide resistance against the devastating powdery mildew fungus, whereas more challenging, complex traits have been altered in corn and tomato. In maize, application of SDN-3 to the Argos8 gene promoter conferred constitutive expression of the endogenous gene and resulted in improved maize yield during drought stress. [2] For the human body, cancer is an example of a lifestyle change that can be made to avoid the fragility caused by cancer, and it is well known that substances that alter the structure of DNA, cause DNA damage and make cells cancerous are known as carcinogens. By minimizing exposure to or intake of carcinogens, maintaining a healthy lifestyle and strengthening the immune system, people are better able to combat the fragility that can be caused by cancer and various diseases.

Reference

[1] Kitano, Hiroaki. Biological robustness.[J]. Nature Reviews Genetics, 2004, 5(11):826. [2] Kwon Y K , Cho K H . Quantitative analysis of robustness and fragility in biological networks based on feedback dynamics[J]. Bioinformatics, 2008, 24(7):987-994.

[2] Gao, C. The future of CRISPR technologies in agriculture. *Nat Rev Mol Cell Biol* **19**, 275–276 (2018). https://doi.org/10.1038/nrm.2018.2