

Question 1:

Biological robustness and fragility are two critical concepts in evolutionary biology for understanding the functioning and evolution process of living organisms. Biological robustness, which is considered as a fundamental feature of evolvable complex systems, refers to an organism's capacity to preserve its structural and functional integrity despite internal and external disturbances, while biological fragility, in contrast, refers to the tendency of an organism to malfunction, or to break down [1].

Biological robustness facilitates evolvability and is essential for an organism's survival [1], as it provides the living organisms the crucial ability to adapt to the ever-changing environment, tolerate the environmental stressor and unstable factors such as reduces in survival resources, temperature fluctuations, and environmental pollution. Additionally, robustness allows organisms to recover to health from injuries and diseases. Immune systems, proteins, cells, biochemical networks, organisms, and natural populations all survive in dynamic, occasionally unfamiliar environments where the preservation of acceptable performance, biological robustness, determines persistence or function [2]. In a human body, an example of biological robustness is the wound healing process, which consists of four phases – coagulation and hemostasis, inflammation, proliferation, and remodeling [3]. In the first phase, the immune system of the body sends platelets to the site of an injury to form a clot, which stops the bleeding and acts as a temporary barrier to guard the wound from further harm and infection. Inflammation is the subsequent phase after the bleeding has been stopped, when white blood cells are delivered to the injured area to help clearing out germs and dead cells, as well as secreting mediators that accelerate the healing process. Proliferation is the stage when the blood vessels are regenerated, and fibroblasts, which produce collagen, begin to reform the tissue around the wound. The new tissue will continue to develop and strengthen in the remodeling process [4].

Human body's vulnerability to certain diseases can be seen as the exposed fragility of robust yet fragile system [1]. The consequences of fragility may include increased susceptibility to illnesses, age-related decline, and less tolerance to environmental stressor such as lack of food and climate change. For instance, due to the defects of their body's defense mechanisms, patients with genetic diseases may be more vulnerable to infections and other health issues. Hemophilia is a genetic disorder brought by mutations in genes that encode clotting factors and results in a deficiency or dysfunction in the healing mechanisms, which makes people more susceptible to both internal and external bleeding [5]. Possible results of hemophilia include pain, chronic joint disease, long-term problems such as seizures, and even death if bleeding happens in a vital organ and cannot be stopped in time [6]. Hemophilia is an example of how a genetic disorder can make the body more fragile, with an increase in the risk of injury and related disease. Effective countermeasures to fragility necessitate a thorough comprehension of a system's behavior and failure pattern. The methods to avoid fragility may include the use of decoys or systematic intervention to address fragility or regulate a system's dynamics [1], such as precision medicine, regular treatment, and corresponding surgery. Gene therapy, for instance, may be a possible solution to Hemophilia, as factor (F) VIII and IX production in milk from transgenic farm animals may be a source of less expensive replacement treatment [7].

In conclusion, biological robustness is a fundamental property of a biological system. Biological robustness and fragility are essential for comprehending the operation of living creatures. While biological robustness allows organisms to adapt to the environment and evolve, in certain cases, due to the exposed fragility, interventions may be required to maintain the robustness of a system. Understanding the concepts behind biological robustness and fragility is vital for gaining insights into the underlying causes of diseases and the development of innovative medications and therapies.

Reference:

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