**Question 1**

According to Kitano (2004), biological robustness could be considered as the feature that when the system is under the external and internal perturbations, its specific functions are preserved [1]. For achieving robustness of many biological networks, feedback loops are widely considered as an important reason. The fundamental mechanisms of biological robustness could be divided into system control, alternative mechanisms, modularity and decoupling. Biological fragility could be considered as the loss of robustness, which also commonly exists in biological networks. For some perturbations, the biological networks could be fragile, although they are robust when meeting more kinds of perturbations. The robustness of biological networks can be lost due to unexpected or unusual mutations, such as point mutation and knockout mutation. Fragility can be measured by the probability of loss of robustness due to unexpected mutations. The robustness and fragility of biological networks are interrelated (Kwon and Cho, 2008) [2].

There are many examples to prove biological robustness. For instance, to resist perturbations, segmental polarity is created by drosophila in its initial values and rate constants of molecular interactions (Ingolia, 2004) [3]. Besides, as for biological fragility, an example is the research of Kitano and Oda (2006), which displays that the dysfunction of MyD88 caused unexpected failure of the immune system, leading to its fragility (Kitano and Oda, 2006) [4]. Some widely-known diseases are also the reflections of biological fragility, such as diabetes mellitus, cancer and HIV infection.

There is no denying that robustness is a fundamental and necessary feature. Because robustness maintains stability and resistance. Robustness is crucial to the stability of biological systems, and its manifestation can be divided into maintenance and change. Maintenance is the ability to maintain the original function and state of the system despite internal and external environmental changes and other factors, which help maintain the stability, resistance and survivability of the system. Change, on the other hand, is the ability to reach a new homeostasis in order to adapt to changes and to have robustness despite the changes, which reflects the adaptation to the environment and other factors. As for survival, both resistance and adaptability are crucial because when meeting many perturbations that could be overcome, great resistance could ensure the stability of survival, and when resistance can not handle the problem, it is necessary to adapt to the environment, which depends on the ability of self-adjusting. And robustness can be used as their evaluation metric. Higher robustness means the better ability for survival, no matter by resisting or self-adjusting. Robustness is important for dynamic systems. For example, it could promote the evolvability of the system. If time is enough, evolution is possible to choose a robust trait that could tolerate perturbations from the environment, which proves the links between the properties of robustness and evolvability. In the evolved biological systems, robustness is ubiquitous. Genetic buffers, robust modules and bow structures are specific architectural requirements for robust and evolvable systems and underlie the robustness of the system to environmental perturbations, but are consistent with genetic perturbations. The generation of flexible phenotypes could be promoted by them (Kitano, 2004) [1].

Biological fragility should strike a reasonable balance with robustness. If this balance is broken and a new suitable balance cannot be developed, there will be a great threat to survival. If the fragility is too great, the ability to resist or self-adjust is weak. The fragility could be caused by some diseases and mutations. To figure out the problem of fragility, taking systematic methods to control robustness of an epidemic state is reasonable, including systematic intervention for controlling system's dynamics, attacking fragility or introducing decoys to rebuild control (Kitano, 2004) [1]. According to the research of Kwon and Cho (2008), it seems that there are more positive feedback loops and less negative feedback loops in the robust networks, and the robust network nodes, which are affected by perturbations, mainly involves less feedback loops than other nodes that are not affected by these perturbations (Kwon and Cho, 2008) [2]. Thus, topological characteristic of the network is also an element determining the robustness and fragility. Taking these principles into use is more likely to find out a reasonable method to solve the problem.

**References**

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