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The Red Queen Effect

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The Red Queen Effect or Red Queen Hypothesis is a term coined by Leigh Van Valen (1973) to explain the ever-changing nature of evolution by natural selection. The hypothesis states that the likelihood of extinction for any given species remains relatively constant over time. Although a species in a given environment may have an advantage at one point in time, this places selective pressure on neighboring species who are themselves constantly evolving. Over evolutionary time, no one species maintains a long-term net advantage because other species that inhabit the same environment will evolve counteradaptations. The term is a reference to Lewis Carroll's *Through the Looking-Glass*:

> "Now, here, you see, it takes all the running you can do to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!" (Carroll 1982, p. 104).

Interspecies Competition

Red Queen effects are exemplified in competition between species, such as the relationships between predators and prey. At any one point in time, predators in a given environment seem well-adapted to catch their preferred prey species, whereas prey seem to be similarly well-adapted to avoid being captured and eaten (Angerbjorn et al. 1999). Over evolutionary time, predator species evolve adaptations that improve their ability to capture prey, whereas prey species evolve adaptations to better avoid capture. A similar dynamic exists in parasitic relationships, wherein parasites are adapted to infect their preferred host species, and host species are adapted to defend against parasites (Brun et al. 1992). A less direct form of interspecies competition exists when two species compete to fill a single ecological niche. For example, if two species occupied the same environment and had similar diets, one species might evolve adaptations either to consume a more diverse range of foods or to outcompete the rival species for the contested food.

Intersexual Competition

The Red Queen Hypothesis can also be applied to opposite-sex members of the same species, as males and females of the same species often have conflicting interests. For example, males have a lower minimum obligatory parental

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investment required relative to females (Trivers 1972). As a result, males are less discriminating when selecting sexual partners and have adaptations that facilitate maximizing the number of sexual partners. Females, in contrast, are more selective when choosing sexual partners, prioritize mate quality over quantity, and often evolve preferences for physical cues to fitness. Males also sometimes have adaptations that increase their ability to circumvent female mate choice by gaining sexual access via force or coercion (Bisazza et al. 2001). In response, females evolve adaptations that guard against coercive sexual advances.

Intraspecies Competition

The Red Queen Hypothesis can also be useful for understanding individual competition between same-sex members of a species. Same-sex individuals of a given species often compete with one another for access to food and mating opportunities. Individuals of some species may even be said to have different strategies, whereby some individuals possess more vibrant physical characteristics that confer an advantage in sexual competition, but a disadvantage in terms of survival. Intrasexual competition over evolutionary time may also result in more exaggerated physical characteristics used to attract mates (Loyau et al. 2005) or better weaponry for competing with same-sex rivals (Robinson et al. 2006). An individual member of a species born with a genetic mutation resulting in a comparative advantage in attracting sexual partners may have an edge in his or her generation. However, such a mutation would be passed down to subsequent generations, eventually becoming a characteristic feature of the species, at which point the mutation could no longer be said to confer an advantage to any one member of the species. Over time, intraspecies competition for resources and mating partners drives the evolution of adaptations to outcompete conspecifics in much the same way that adaptations result from interspecies and intersexual competition.

Cross-References

- ▶ Cuckoo Brood Parasitism
- ▶ Intra-sexual Selection
- ▶ Predator
- ▶ Runaway Selection
- ▶ Sexual Selection

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