

Natural Selection is not an Invisible Hand

Natural selection is a metaphor. Metaphorical phrases are common in evolutionary biology, and once understood they can be powerful ways to illustrate dry scientific concepts. But all too often metaphors are not identified as such, leaving students and professional scientists alike open to misconceptions. One common misconception is that natural selection is a purposeful agent, an invisible hand¹ that causes change or chooses among organisms to fulfill some agenda such as efficiency, the needs of an individual, group, or species. When evolutionary biologists use phrases like "individuals are selected to maximize reproductive success" or "natural selection has favored apes with big brains" they are speaking metaphorically, but might unwittingly reinforce this kind of misconception.

To understand the principle called "natural selection", it is useful to think through a couple of little experiments. Here is one I do with some of my classes. First, give some students each one coin and give others each one six-sided die. Let them flip their coins and roll their dice once each, and record the results. Classify individuals with heads or numbers less than six as "survivors" and those with tails or a six as "dead". Usually there will be proportionately more survivors with dice than with coins because the probability of survival is $5/6$ vs. $1/2$. If we calculate the ratio of survivors with dice, we expect it to be greater than the original ratio of students with dice.

The main principle being illustrated here is *if, within a given set of organisms, there are intrinsic differences in probability of survival, then the composition of the set will usually change, becoming more biased toward individuals with higher survival probability*. This is a subset of "natural selection" called "viability selection", but notice that no one is literally selecting survivors. Survival happens or not by chance.

If more dice-bearers survive than coin-bearers, it is *as if* someone had deliberately chosen more of the dice-bearers to survive. But in fact, dice bearers were simply more likely to survive as a natural consequence of their morphology: they had five ways to survive and one way to fail, whereas the coin-bearers had only one way to survive and one way to fail.

A secondary principle illustrated by the experiment is that the process referred to as natural selection is a stochastic, not deterministic process. Every once in a while (especially in a small class), there will be more survivors with coins than with dice. There is nothing wrong with this outcome.

So, why is it called "natural selection" if there is no purposeful selector? Darwin made up the name because some of his key insights were drawn from "artificial selection". Artificial selection is the deliberate selection, by animal and plant breeders, of particularly desirable individuals. Breeders literally select who gets to be the parents of a new generation. In this way, they often directly cause evolution of domesticated species. If all goes according to plan, this directed evolution produces populations with desirable traits, for example, fatter pigs, friendlier dogs, and prettier roses. The principle of natural selection is that populations in nature can be expected to change *as if* an unseen breeder were selecting individuals with certain traits, because certain traits make it more likely that an individual will survive and reproduce.

¹ The phrase "invisible hand" was coined by Adam Smith in *The Theory of Moral Sentiments* (1759) in reference to his idea that people pursuing only their own self-interest frequently promote the interest of society as a byproduct, as if "led by an invisible hand". This metaphor, too, has been the subject of much confusion and disagreement.