Fit for Life – Introduction to Adaptation and Natural Selection

Scientific Investigations Using Computation
Angela B. Shiflet and George W. Shiflet
Wofford College

Introduction

Snorkeling or diving along part of Australia's Great Barrier Reef (GBR), you see an incredible variety of organisms. Large heads of hard corals surround you. More than 70 species of hard coral species here, out of 411 total species, are capable of forming the actual reefs. The reefs are beautifully festooned with an array of other plants and animals. You see soft corals like sea fans waving in the current and massive barrel sponges, which are some of the 1500 species of sponges on the GBR (WWF). There are plant-like anemones, a myriad of small crustaceans, colorful sea stars, sea urchins and sea feathers, various worms, clams, and colorful nudibranchs going about the business of nourishing themselves. Of course, you also see a dazzling assemblage of larger animals, like fish, shark, turtles, and perhaps a sea snake. You marvel that these organisms display significant and appropriate characteristics or adaptations that allow each species to survive and reproduce on the reef.

Although, the Great Barrier Reef likely represents the most diverse **ecosystem** on the planet, you can find great diversity all over the globe, in every type of ecosystem. Human beings have long wondered about the diverse communities of organisms that populate the earth and pondered their origins.

Animal Diversity: The Mollusks

Imagine yourself walking down a sandy beach, enjoying the sunshine and gentle ocean breezes. As you gaze, you see that the sand is littered with various types of shells. As it happens, the creatures that produced most of these shells belong to an animal phylum called the Mollusca. Experts claim that the mollusks are one of the most diverse groups of animals on earth and that there may be as many as 200,000 living species. Even though there is great variety in **morphology** (body structure), they all possess a soft body, composed of a "head," a visceral mass, and a "foot." Frequently, a calcareous cover, or shell, encloses and protects their soft bodies. Some of the shells you find there still contain the organism that produced them, but many of the shells are just remnants of former life. Familiar examples of mollusks include snails, clams, squid, oysters, and chitons (UCMP). Consider for a moment how different those animals appear. How is it that such disparate creatures are all considered mollusks?

The mollusks are a large and varied animal group, and each member of that group embodies a collection of adaptations. **Adaptations** are traits or characteristics that improve an organism's chances to survive in their environment and subsequently produce more progeny. Adaptations are generally considered to be a result of **natural selection**. When Charles Darwin proposed the process of natural selection, he based his hypothesis

on several principles he developed based on his data and observations (University of Michigan 2010):

1. There is some morphological, physiological, and behavioral variation within populations of organisms.
2. Many of the traits that characterize organisms are heritable. We now refer to the genes that produce these traits **genotypes** (genetic makeup of an organism). We also know **mutations** occur that change genes and gene expression. Most of these changes are detrimental or neutral, but occasionally they are advantageous.
3. Populations tend to produce numbers of offspring that exceed the capacity of the environment to support. There is, then, a struggle for existence among the members of the population.
4. Members of the population that have traits that confer a competitive advantage (adaptations) over other members will have improved chance to survive and reproduce. Hence, these members will contribute more offspring, also with similar adaptations, to the next generation.

Thus, natural selection is a process that alters the relative frequencies of different genotypes in a population, changes that result from differences in the ability of the resulting **phenotypes** to survive and reproduce. Reproductive success is synonymous with **biological fitness**. Therefore, if a mutation yields a new genotype that increases the fitness of the organism, more of this genotype successfully reproduce, and more of this genotype should appear in the next generation. If the environment remains consistent, the frequency of the genotype will continue to increase accordingly.

Let's reiterate what we mean by **genotype** and **phenotype**. **Genotype** is the set of genetic instructions that determine physical and functional characteristics of an organism. The physical expression of the genotype is termed the **phenotype**. For example, if a mouse has genetic instructions for gray fur color, the gray color is the expression of those genes – the phenotype. If another mouse has a variation of that same set of genes that code for white fur color, the phenotype would be white. (These alternative forms of the same gene are termed **alleles**.) Suppose that these animals live in an area where the soil is gray. With such a background, the gray mouse blends in with the soil color better, and therefore a predator would be less likely to spot the mouse. Conversely, a predator is more likely to catch and eat a white mouse, which stands out against the soil. Hence, more gray mice will survive to reproduce and pass on the genes coding for the gray phenotype.

Quick Review Question 1 Distinguish between a phenotype and genotype.

Quick Review Question 2 What is natural selection?

Quick Review Question 3 What are the principles upon which Darwin based his ideas on natural selection?

Quick Review Question 4 What are alleles?

Quick Review Question 5 Which mouse, gray or white, has better fitness? Under what conditions? Why? In the next generation, which color of mouse is more likely to survive to reproduce?

Glossary

adaptation - traits or characteristic that improve an organism's chances to survive in their environment and subsequently produce more progeny.

alleles – alternate forms of the same gene

biological fitness – reproductive success; capability of an organism to survive for reproduction, increasing the proportion of its genes in the succeeding generation

ecosystem – a community of living organisms and their environment

genotype – genetic makeup of a cell, organism or individual

morphology - body structure

mutation – alteration made in the gene, which may lead to a change in gene expression

natural selection – the effects of forces that determine comparative reproductive success of various genotypes in a population. In nature, this process will promote the survival of the best-adapted organisms, ensuring that they will reproduce, and their offspring, which have their genes increase in proportions of succeeding generations.

phenotype – physical expression of the interaction between the individual's genes and the environment.

References

UM (University of Michigan). 2010. Evolution and Natural Selection. http://www.globalchange.umich.edu/globalchange1/current/lectures/selection/selection.html (accessed March 3, 2014)

Another example: Peppered Moths
Preparation for Lab on Wednesday 19 April 2017:

1. Read https://askabiologist.asu.edu/peppered-moth

2. Download and open in NetLogo:

http://www.shodor.org/~rpanoff/CS150/NetLogoModels/PepperedMothsRev.nlogo

and read, then re-read, the information under the INFO tab.

(This information will make the lab go better. All the information in this handout will be quizzed on Thursday.)