Barnacles, Genes, and Natural selection. What is happening?

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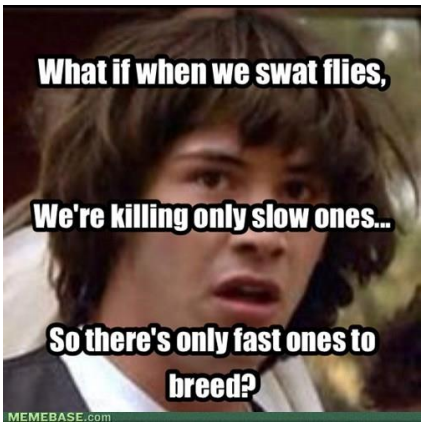
When you look at the picture above you probably recognize the creature on it as a barnacle. But that's it. You probably don't know anything else about it even though it's *literally* everywhere! Acorn barnacles, specifically, are way more interesting than what you would think. Acorn barnacles can live in intertidal zones, boats, hulls, underwater volcanoes, and even on whales (Lopez et al. 2010). Nowhere is safe from these things! They are also extremely useful for the environment. Barnacles are considered filter feeders and mainly eat plankton and detritus (dead organic material). Without them, a lot of dead animals would be floating around in the ocean and polluting it as well (Tallis 2009)

Barnacles are fascinating animals whose behaviors are dictated by the tides of the ocean. In the picture above, you can see some are barnacles open and closed. Those that are closed are prepared for when the waves are about to impact them. When the waves hit the barnacles, they have a way to drag food (such as plankton) into their shell to feed on them. Also, during the winter, they avoid eating and rely on energy reserves due to the change in temperature (Thiyagarajan and Harder 2003).

For about 20 years, a ragtag team of scientists has studied the acorn barnacles (or as scientists would call it, *Semibalanus balanoides)* to see if their genes undergo natural selection. Now, folks, I bet you are asking yourself, "What is natural selection?" Natural selection is when organisms who are better suited for the environment have a better chance of surviving and leaving offspring. Now imagine yourself on your bed late at night, you've had a long day, and you're trying to sleep. When suddenly you hear an annoying sound that is disturbing your long-

deserved rest. You look up and see two flies, so you decide to kill the flies and go back to sleep. The flies are fast though, so when you try to kill both of them, it's very difficult. You then decide to kill only one fly, the slower of the two flies. That fly would be the easier one to kill. You then kill one fly, which makes the other one fly away in fear, and now you can return to your bed and go to sleep. The main point is this: we kill the slow flies, which allows the fast flies to reproduce. The fast flies are better suited to the environment, so they will live longer and produce more offspring. If the fly's speed is due to a genetic trait, then their children will also be fast and hard to kill.



So, researchers are trying to see if some barnacles are better than others based on their genes. For the last 20 years, scientists have looked specifically at the mannose-6-phosphate isomerase locus in barnacles. We'll call it the mpi gene. A locus is just a specific place on a chromosome. In other words, the scientists are only looking at one location in the chromosome of barnacles to see if there is a variation from the norm.

Now, why would anyone waste 20 years of their life studying barnacles? The mpi genes are actually really important. It is the key enzyme in energy metabolism (Nunez et al. 2020). If this gene changes, then there will be genetic variation, something for natural selection to act on. Due to this, whichever barnacle has a version of the gene that is better equipped for its environment, that barnacle will survive longer and produce more offspring. I think that it's important to know that even something as small as a singular gene change can have a grand impact on an organism. All of the barnacles at the top look exactly the same, but one small change that is not noticeable on the outside can lead to a **huge** difference in competition. The barnacles with slow mpi genes can possibly outcompete those with fast mpi genes, or vice versa.

The mpi gene needed to be analyzed to see if there were any genetic differences between barnacles. To do this, scientists did a phylogenetic analysis to look into the gene. This process is pretty simple and refers to when someone sequences (or reads) a gene to know what's in it. The scientists did this on the mpi gene to know if natural selection is happening and to see if there are any significant changes in the gene. The researchers found that there were three different mutations in the mpi gene that can cause a significant change. Due to this, two types of barnacles were formed, one with a fast allozyme mpi gene and the other with a slow allozyme mpi gene (Nunez et al. 2020). An allozyme is a different form of an enzyme, which has some sort of charge. Some have a positive charge (these are called fast), and some have a negative charge (these are called slow). Ironically, the fast allozyme gene refers to the metabolism of the barnacle being slow and the slow allozyme refers to the metabolism being fast. The next thing the scientists wanted to know was the effects this had on the barnacle's fitness. Did one mpi gene outcompete the other?

What was found was very inconclusive. As we have previously mentioned, barnacles live basically anywhere near water. Logically speaking, these different environments would have different effects on the animals. In one environment, the fast mpi gene was better than the slow one, and the opposite was true in other environments. An example of this would be in intertidal zones, where some barnacles will live on rocks that are underwater, and other barnacles would be on the same rock but on the portion that would be above water. Even though the difference between these barnacles is only a few feet at most, their living conditions are completely

different. Those that live underwater are in a less stressful environment because barnacles like the water, it is where they get their food. Barnacles like to live near the water, when they live above the water they face high levels of heat, without water they have no way to cool down and regulate their body temperature. While those that live above water are under more thermal stress and have less access to food (Nunez et al. 2020). This is referred to as thermal stress and can lead to the barnacle overheating. Mpi fast genes add thermal resistance to any organism that has this. Due to these factors, mpi slow genes were favored underwater while those that had mpi fast genes were favored above water.

Though mpi fast genes were favored above water and mpi slow were favored underwater, this does not always seem to be the case. It was once assumed that this was the case for all intertidal regions, but each intertidal area is unique (Nunez pers comms 2021). When this study was conducted in the intertidal regions of Maine, it was found that the fast genes were found above water, and the slow genes were found underwater—as was expected. But, when this study was conducted in the intertidal region of Rhode Island, this was not the case. The exact opposite was seen. The slow genes were found above the water, and the fast genes were found underwater. The reason for this is not known for certain, but scientists have proposed the idea that it is due to the difference in tidal range and the timing of low tides. The tides in Rhode Island are greater than the tides in Maine, this can lead to thermal stress varying across the intertidal region, which could lead to the mpi genes not following the patterns found in Maine (Nunez et al. 2020).

As you can see, there is not one outcome for the mpi gene. This is confusing, but one thing is for certain: that natural selection was occurring in barnacles. In environments that are underwater mpi slow genes outcompeted the fast ones and were easily able to reproduce (mostly). This is because the barnacles with a slow metabolism were able to combat thermal stress better than barnacles with a fast metabolism (Nunez et al. 2020). Scientists found that the barnacles were undergoing balancing selection. This is when multiple genes are in the population, and no allele will "win" and be found in all barnacles. In this example, no allele will die out because they are both good in different scenarios. Many factors are at play with different environments applying different types of stress to the barnacles. At the moment scientists do know that both mutations are important. This study shows though animals, like barnacles, may seem all the same, very tiny unnoticeable differences affect their ability to survive and can have a dramatic effect on the outcome of competition and habitat space

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Pic links:
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