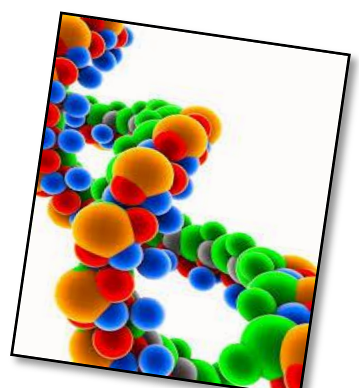
TEACHER BACKGROUND:
ECOSYSTEM RESPONSE TO CLIMATE CHANGE

Global warming is, quite literally, a hot topic. Though the process of global warming may not be big news, the projected impact often makes headlines. Documentary films on the topic have focused even more attention on the potentially disastrous effects of even a few degree temperature increase. Whole island countries could disappear into the ocean as polar ice melts and sea level rises, hurricanes and tropical storms may intensify and ecological interactions could change in unpredictable ways. Increasingly, it seems global warming shows up on the front page of the newspaper — but the evolutionary implications of global warming often remain hidden.

For example, melting sea ice may be forcing some polar bear communities in the Arctic into cannibalism now that fewer seal hunting opportunities are available. As global warming has caused Arctic Sea ice to start melting earlier and earlier each summer, as well as causing more of it to melt, some polar bear populations have been adversely affected. As the sea ice declines, bears can spend less time on the sea ice hunting their preferred prey, seals. Lower food (seal) access results in thinner, more aggressive bears. Left without their usual prey, the bears will occasionally resort to a disturbing behavior: cannibalism. A smaller bear represents a potential source of food.



Global warming is certainly a climatic and environmental issue — but it is also an evolutionary one. Over the past 20 years, biologists have uncovered several cases of evolution right under our noses — evolution caused by global warming. One of the key processes of evolution, ***natural selection***, causes organisms to evolve in response to a changing environment. Imagine a population with several different variations in it: some individuals happen to be better able to survive and reproduce at higher temperatures than others. If the temperature increases, heat tolerant individuals will have an advantage and will leave more offspring — and those offspring will also carry the genes for heat tolerance. Over many generations, this process produces a population with adaptations suited for the hotter environment. So long as the population has different genetic variations in it, some better able to survive and reproduce in particular situations than others, the population has the capacity to evolve when faced with a changing environment.

Over the past 25 years, global surface temperatures have increased about .5°F. That might not sound like much, but it turns out to be more than enough to change the ecology and evolution of life on Earth. In many cases, these changes are simply non-evolutionary examples of ***phenotypic plasticity***, where an organism expresses different traits depending on environmental conditions. For example, many organisms respond to warmer weather by reproducing earlier and taking advantage of an earlier spring — but this early reproduction is not caused by genetic changes in the population and so is not an example of evolutionary change. Similarly, many species have shifted their ranges in response to this tiny temperature difference, spreading towards the poles, as those habitats warm — but this change in range cannot be traced to a genetic shift in the population and so is not an example of evolution. And still other species simply seem to be on the path to endangerment or extinction as their habitats (like coral reefs) are degraded and their population sizes drop.

However, in a few cases, we know that species have actually evolved — experienced a change in gene frequency in the population — in response to global warming. Interestingly, in those cases, the species are not necessarily becoming more heat tolerant, but are adapting to changes in seasonal timing:

- **Canadian squirrels** are evolving to take advantage of an earlier spring and are breeding sooner, which allows them to hoard more pinecones for winter survival and next year's reproduction. Squirrels with genes for earlier breeding are more successful than squirrels with genes for later breeding.

- **European great tits** (a type of bird) are also evolving different breeding times. Birds that are able to adjust egg-laying to earlier in the spring can time hatching so that it coincides with greater food (caterpillar) abundance — and with recent climatic changes, the caterpillars have been maturing earlier in the spring. Birds with genes for more flexible egg-laying times are more successful than birds with less flexibility in their egg-laying.

* One **North American mosquito** species has evolved to take advantage of longer summers to gather resources while the weather is good. Mosquitoes with genes that allow them to wait longer before going dormant for the winter are more successful than mosquitoes that go dormant earlier.

In a sense, these populations are the lucky ones. Small animals generally have large population sizes and short generation times — and because of that their ability to evolve along with a changing environment is relatively assured. Large population size means that the species is more likely to have the genetic variation necessary for evolution, and having a short generation time means that their rate of evolutionary change may be able to keep pace with environmental change. However,

other species may not be so lucky: larger animals tend to have longer generation times and so evolve more slowly — and larger animals also tend to have smaller population sizes, which means that their populations are simply less likely allow the population to adapt to warmer climates. If global warming continues, such species may come face to face with ***extinction,*** since the environments they have been adapted to over the course of thousands or millions of years change right out from underneath them in the course of a few decades.