Evolution & Natural Selection

Name ____

Introduction

Evolution is the most important unifying principle in all of biology. Every living organism on the planet today looks, functions, and behaves like it does because of evolution. This is true regardless of whether we are looking at cells, individuals, populations, or even entire ecosystems – all are (and have been) shaped by evolutionary processes.

The **definition of biological evolution** is:

> A change in the genetic make-up of a population over time. These genetic changes result in visible changes among members of the population.

The primary mechanism of evolutionary change is the process of **natural selection**. You should recall from lecture that several conditions are necessary for natural selection to occur:

1. **Variation**. Individuals within a population must be different from each other.

2. **Inherited Basis**. Some of the variation among individuals must have a genetic basis. Thus offspring will tend to resemble their parents and have the same traits.

3. **Differential Survival and Reproduction**. Individuals with some traits will survive longer and leave more offspring relative to others in the population.

Given these conditions, certain traits will gradually become more common in the population, while others will become less common. In effect, the environment, or nature, "selects" some traits over others. It is this process of natural selection that brings about evolutionary change.

Purpose

The primary purpose of this exercise is to demonstrate how natural selection works to bring about evolutionary change. It will illustrate:

- the key features of natural selection and the role they play in the selection process.
- how variation in the amount of variation of a trait can affect selection.
- how variation in differential mortality can affect selection.
- a common misconception of natural selection.

Procedures and Questions

Natural Selection Simulation

Given that evolutionary theory is the most important unifying principle in biology, it is just as important to understand natural selection. The problem is that under most conditions the process of natural selection is relatively slow, occurring over many generations. Fortunately, by using a simulation, we can speed up the process and study how natural selection works in a much shorter time period.

You are going to run several simulations on the EvoTutor website. To get there, type in:

> **http://www.evotutor.org/Selection/SelectionA.html** (NOTE: you must type in this address exactly like I've typed it above [capitalize the S's and the A] or it won't work)

If this worked correctly you should be looking at a screen with the title **EvoTutor** and you should be on the page called **Natural Selection**. Under Natural Selection is a menu with several buttons that will take you to a variety of simulations. You will complete the **Requirements**, **Variation**, and **Mortality** simulations.

<u>Requirements</u>

Click on **Requirements**. Read the information provided. Click on the tabs along the left side of the window to see more information.

> *Note: This program uses **Differential Mortality** instead of **Differential Survival and Reproduction**. Although both can have the same effect on natural selection, an underlying assumption of differential mortality is that everyone that stays alive will mate. You should be aware that this is not always the case in natural populations, and thus differential reproduction is a more realistic requirement.*

This set of simulations will allow you watch how natural selection works in "populations" where one or more of the three requirements are met. You can decide which requirements are met by checking and unchecking the boxes under the graph. You can also change the type of graphical display by selecting one of the boxes at the top. I suggest doing each simulation twice – once with the "population" box checked, and once with the "Histogram" box checked. This will give you a more complete picture of what is happening.

To run each simulation, choose which requirements you want present and how you want it displayed. Then click on the "Run" button. The simulation will run for a few seconds and then stop.

1. What happens to the population when none of the requirements are met? (Hint: I'm looking for things like: nothing, it stayed the same; or it started out mostly pink and then ended up mostly green)

2. What happens when only one or two requirements are met?

3. What happens when all of the requirements are met? (I.e. all of the boxes are checked.)

4. Based on what you saw in these simulations, what did you learn about natural selection?

<u>Variation</u>

To get back to the Natural Selection menu, click on the white arrow in the upper left corner of the EvoTutor window. Now click on the **Variation** button.

This series of simulations will demonstrate how the amount of variation present in a population can affect natural selection. Populations with a large amount of variation can typically adapt more quickly to changing environments. Populations with little variation change more slowly, and are more susceptible to extinction.

> *Note: In this simulation, we are lumping "general" variation and genetics together. The use of variation refers both to genetic variation and visible variation in a trait.*

To run each simulation, choose the amount of variation you want by moving the small scroll bar located under "Variance" at the bottom of the window. You can adjust the variation from 0 (no variation) to 2000 (a lot of variation). I suggest running the simulation with a small, medium and large amount of variation. To start the simulation, click on the "Run" button.

Just like before, you can change the type of graphical display by selecting one of the boxes at the top. Again, I suggest doing each simulation twice – once with the "population" box checked, and once with the "Histogram" box checked.

1. What happens when the amount of variation is small?

2. What happens when the amount of variation is medium?

3. What happens when the amount of variation is large?

4. What did you learn about variation and how it affects natural selection?

Mortality

Go back to the Natural Selection menu and then click on the **Mortality** button.

This series of simulations will demonstrate how the degree of **differential mortality** of a trait can affect natural selection. Different traits confer different levels of benefits or costs to your chance of survival or reproduction. This difference then affects the intensity of natural selection either **for** or **against** that trait. For instance, let's consider a trait where some individuals have red feathers and some have yellow feathers. Individuals with yellow feathers survive only a little bit longer or produce only a few more offspring than individuals with red feathers – the differential mortality or reproductive success of this trait is small. In this situation, selection **for** having yellow feathers and **against** having red feathers will be weak. This means that any changes in the trait (evolution) are likely to be fairly slow to occur. On the other hand, if individuals with yellow feathers live much longer or produce many more offspring than individuals with red feathers (differential mortality or reproductive success is large), then selection **for** having yellow feathers and **against** having red feathers will be strong and changes in the trait (evolution) are likely to occur fairly quickly.

To run each simulation, choose the degree of mortality you want by moving the small scroll bar located under "Mortality" at the bottom of the window. You can adjust mortality from 0 (no difference in mortality) to 1 (maximum difference). I suggest running the simulation with no, a little and maximum mortality. Again, you can change the type of graphical display by selecting one of the boxes at the top. To start the simulation, click on the "Run" button.

1. What happens when there is no mortality difference?

2. What happens when there is a small mortality difference?

3. What happens when the mortality difference is at its maximum?

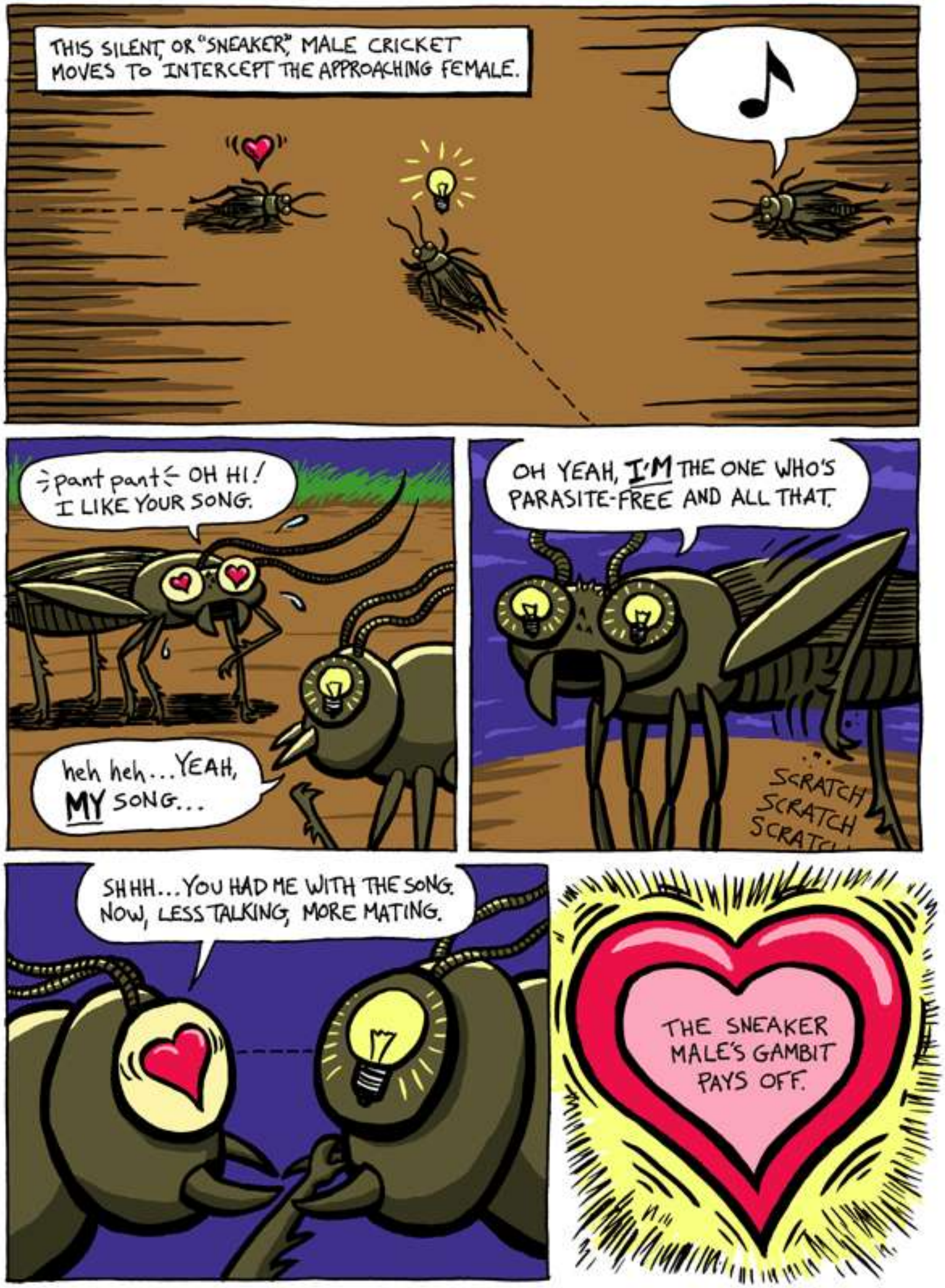
4. What did you learn about differences in mortality and how it affects natural selection?

Survival of the Sneakiest ***by the Understanding Evolution team***
(http://evolution.berkeley.edu/evolibrary/article/sneakermales_01)

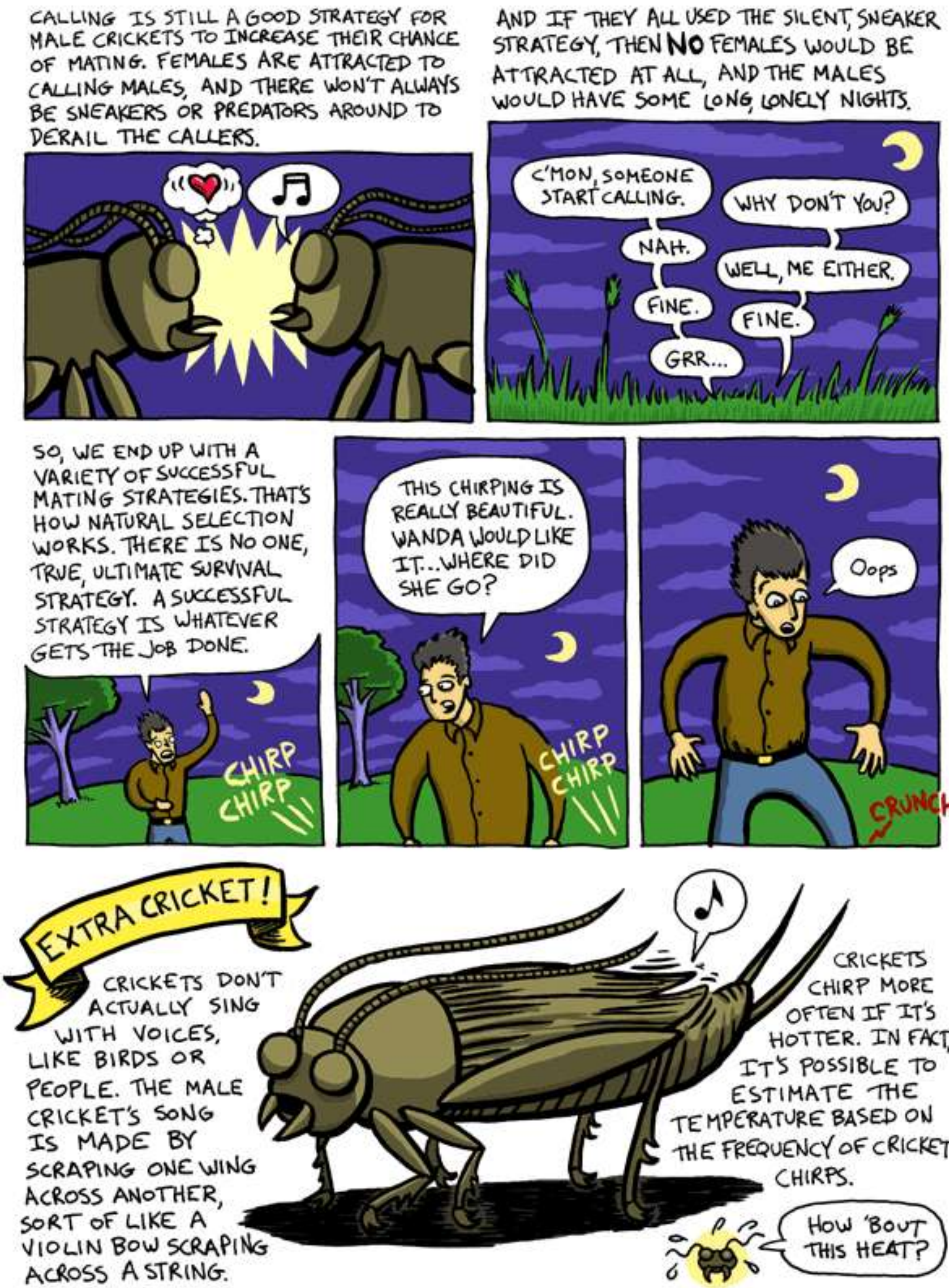
If "Survival of the fittest" means that only the strong succeed, then the weak fail, right? Well, often that's how it's portrayed, but the real story is a bit trickier. The following cartoon provides another example of why this phrase is often interpreted incorrectly. Read it and answer the questions at the end.

The ROYAL SOCIETY of COMICS presents
AH... THE MOON, STARS, A GENTLE BREEZE, CHIRPING CRICKETS... LOVE IS IN THE AIR, WANDA. IT'S A PERFECT NIGHT FOR...
Survival of the SNEAKIEST
...LESSONS IN THE MATING HABITS OF CRICKETS AND NATURAL SELECTION!
ARGH... I'LL GO WAIT IN THE CAR.
NATURAL SELECTION: WE'VE ALL HEARD IT EXPLAINED AS "SURVIVAL OF THE FITTEST." THE STRONGEST AND FASTEST WIN. IF YOU'RE TOO WEAK OR SLOW, WELL, TOO BAD, RIGHT?
GRR!
NOT QUITE. LET'S START WITH A SINGLE, MALE CRICKET.
OUR GUY IS A BIG, HEALTHY SPECIMEN— STRONG, CONFIDENT, AND LOOKING FOR LOVE!
WHAT FEMALE WOULDN'T WANT A PIECE OF THIS?
mi mi mi
cough
a one, and a two, and...
HELLOOo LADIES!!!


NOT FAR AWAY, A FEMALE CRICKET LIKES WHAT SHE HEARS...
OH YEAH! MY EXOSKELETON IS SOOO GLOSSY! I'M PARASITE FREE!
OH MY!
THAT'S ONE HUNKA HUNKA BURNIN' CRICKET! JUST THE KIND OF MALE I WANT TO FERTILIZE MY EGGS!
drool!
SO, SHE HEADS OFF TOWARD THE CALLER, FOLLOWING THE SOUND.
MEANWHILE, IN A NEARBY BURROW
OH GIRL, YOU MAKE MY ANTENNAE TREMBLE! TOGETHER WE CAN MAKE EXTREMELY FIT OFFSPRING!
WILL YA LISTEN TO THIS BLOWHARD?
I MEAN, I WANNA MATE AS MUCH AS THE NEXT GUY CRICKET, BUT YOU DON'T HEAR ME ANNOUNCING IT TO THE WHOLE MEADOW.
ACTUALLY, THAT GIVES ME AN IDEA.
HOP!


THIS SILENT, OR "SNEAKER," MALE CRICKET MOVES TO INTERCEPT THE APPROACHING FEMALE.
♪
≑pant pant≑ OH HI! I LIKE YOUR SONG.
heh heh... YEAH, MY SONG...
OH YEAH, I'M THE ONE WHO'S PARASITE-FREE AND ALL THAT.
SCRATCH SCRATCH
SHHH... YOU HAD ME WITH THE SONG. NOW, LESS TALKING, MORE MATING.
THE SNEAKER MALE'S GAMBIT PAYS OFF.


AND OUR ORIGINAL, STRONG, LOUD, CALLING MALE IS OUT OF LUCK.
LAST CHANCE FOR YOU SPECIAL LADIES TO... uh... MEET A REALLY GREAT GUY..?
AW, FORGET IT.
IN FACT, HIS SONG HAS ATTRACTED SOME UNWANTED ATTENTION.
I'M ALMOST THERE... KEEP CHIRPING, YOU BIG, JUICY BOZO!
FEETS, DON'T FAIL ME NOW!
SO, IN THIS CASE, THE SNEAKER MALE GETS TO MATE, AND THE SINGING ATTRACTIVE MALE GETS EATEN BY A BAT.
ERK!
SNATCH!
SEE, "SURVIVAL OF THE FITTEST" ISN'T NECESSARILY ABOUT BEING THE TOUGHEST, FASTEST, OR MOST ATTRACTIVE. IT'S REALLY ABOUT SURVIVING TO PASS THE GENES THAT ENCODE TRAITS AND BEHAVIORS ON TO OFFSPRING
MAYBE OUR SNEAKER MALE'S KIDS WILL INHERIT THE "SNEAKY" GENES, AND IN TURN USE SNEAKY BEHAVIOR LIKE THEIR FATHER.
WHY WASTE OUR ENERGY SINGING WHEN SOMEONE ELSE WILL DO IT FOR US?
I'M NO CHUMP.
HEH HEH.
OF COURSE, TOUGHNESS CAN HELP TO INCREASE AN ORGANISM'S CHANCE OF LIVING LONG ENOUGH TO REPRODUCE...
ROARR!!!
RETREAT!
...BUT REPRODUCTION AND THE PASSING ON OF GENES ARE MOST IMPORTANT IN TERMS OF EVOLUTION. AND THERE ARE MANY WAYS THAT AN INDIVIDUAL CAN GET THEIR GENES INTO THE NEXT GENERATION.


CALLING IS STILL A GOOD STRATEGY FOR MALE CRICKETS TO INCREASE THEIR CHANCE OF MATING. FEMALES ARE ATTRACTED TO CALLING MALES, AND THERE WON'T ALWAYS BE SNEAKERS OR PREDATORS AROUND TO DERAIL THE CALLERS.
AND IF THEY ALL USED THE SILENT, SNEAKER STRATEGY, THEN NO FEMALES WOULD BE ATTRACTED AT ALL, AND THE MALES WOULD HAVE SOME LONG, LONELY NIGHTS.
C'MON, SOMEONE START CALLING.
WHY DON'T YOU?
NAH.
WELL, ME EITHER.
FINE.
FINE.
GRR...
SO, WE END UP WITH A VARIETY OF SUCCESSFUL MATING STRATEGIES. THAT'S HOW NATURAL SELECTION WORKS. THERE IS NO ONE, TRUE, ULTIMATE SURVIVAL STRATEGY. A SUCCESSFUL STRATEGY IS WHATEVER GETS THE JOB DONE.
CHIRP CHIRP
THIS CHIRPING IS REALLY BEAUTIFUL. WANDA WOULD LIKE IT...WHERE DID SHE GO?
CHIRP CHIRP
Oops
CRUNCH!
EXTRA CRICKET!
CRICKETS DON'T ACTUALLY SING WITH VOICES, LIKE BIRDS OR PEOPLE. THE MALE CRICKET'S SONG IS MADE BY SCRAPING ONE WING ACROSS ANOTHER, SORT OF LIKE A VIOLIN BOW SCRAPING ACROSS A STRING.
CRICKETS CHIRP MORE OFTEN IF IT'S HOTTER. IN FACT, IT'S POSSIBLE TO ESTIMATE THE TEMPERATURE BASED ON THE FREQUENCY OF CRICKET CHIRPS.
HOW 'BOUT THIS HEAT?

Questions:

1. When it comes to crickets (or any organism, really), what does fitness mean?

2. Is calling good or bad for a cricket's fitness? Explain.

3. Give some examples of selection at work in this cricket story.

4. How does selection favor calling? How does selection favor not calling?

5. Using your understanding of Evolutionary Game Theory, explain how these two strategies (calling and sneaking) can coexist in this population of crickets?