Name:____________________ **Period: _____**

Peppered Moth Evolution Simulation Lab

AP Bio Learning Objectives:

1. LO EVO-1.E: Describe the importance of phenotypic variation in a population

Record your results and responses on a separate sheet of paper. Title it "Peppered Moth Evolution Simulation Lab" and complete the following steps.

PART 1: Background, and a simple model of selection

1. **Introduction section**: Go to https://askabiologist.asu.edu/peppered-moth and summarize each of the major sections (*Blending In*, *A Pick of Pepper*, *From Light to Dark Moths*, *A Changing World*, *The Pepper in Peppered Moth*, *Natural Selection in Action*). A few sentences for each of these sections is probably sufficient.
2. Under the "Changing Colors" heading, click on the image that's titled "Peppered Moths," natural selection in action. This will take you to the "Peppered Moth Game."
3. At the main menu, click on each of the menu items on top from left to right, and take brief notes on each major section.
   a. Peppered Moth (which will tell you about the life cycle of the moth, and its predators)
   b. Natural Selection
   c. Dr. Kettlewell
4. Read "How to Play," and then play the game. Set up a simple data table to record what happens as you play. Make sure you run simulated experiments in both types of forest (light and dark). Please turn the volume on your computer way down.
5. Write a brief summary of what you've learned so far. Specifically: .
   a. What did you learn from this entire activity (reading plus the simulation)?
   b. Spend about 5 minutes reading about scientific models at http://sciencelearn.org.nz/Contexts/The-Noisy-Reef/Science-Ideas-and-Concepts/Scientific-modelling
   c. The "Bird's Eye View" activity was a model. Was it a good model? What were some of its strengths? Weaknesses?

PART 2: A more complex model

1. With the model that we're about to use, you can do some more complex experimentation with peppered moth evolution. Here's a few important points to help you design your experiments.
   a. Experiments have **independent variables**. These are variables that you control. For example, if you were experimenting with the effect of different colors of light on plant growth, your independent variable would be the color of the light.
   b. Experiments have **dependent variables**. These are the measured outcomes. In the experiment above, the dependent variable would be the amount of plant growth.
   c. A well designed experiment attempts to establish causation by **only testing one variable at a time**. An experiment set up in this way is a controlled experiment.
2. Launching the model: Click this link or search for "NetLogo Web" or go to http://www.netlogoweb.org. Select the "NetLogo Web" button on the left, and then search for Peppered Moth in the models library.

3. Your job is to run a series of experiments using this model. It's pretty self explanatory, but the following might help.
    a. Click the "setup" button on the far left to populate your model with moths.
    b. On the sliders on the left you have a few of your *independent variables* (the ones you manipulate)
        i. Num-moths
        ii. Selection
        iii. Mutation
        iv. Speed
    c. Two (super-important) additional *independent variables* are controlled through two buttons on the upper left that let you...
        i. *Pollute* the environment
        ii. *Cleanup* the environment
    d. You can see the amount of pollution in the yellow readout fields in the lower left of the model. If you click on the "Pollute" button, you'll see the amount of pollution change. You'll also see the "environment" become darker.
    e. You can get numerical data about your initial settings and the progress of the model (including your dependent variables (light moths, medium moths, and dark moths) in the other yellow field boxes in the lower left.
    f. The "Go" button starts the simulation, and also lets you pause it.
4. A few tips about how to proceed.
    a. Start by establishing a **baseline**. The best way to do this is to use the default variables (which is what you get when you click "setup", and then compare this to your subsequent experiments. In other words, the baseline serves as a control.
    b. Note that the equivalent of time in this simulation is *ticks*. 100 ticks should probably be enough (but watch to see if things are changing: if they are, then allow more time.

BASELINE:

Independent Variables (you set these)				Dependent Variables/Outcomes		
Total Number of Moths	Selection	Mutation	Pollution level (%)	Total Light Moths	Total Medium Moths	Total Dark Moths
100	50	15	0			

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5. Running Experiments: In each experiment, you change **just one thing.** That way, you can see the results of varying that variable. You can compare this to the baseline or to the previous experiment.
6. In your notes, set up a series of data tables that look something like this:

TRIAL # ___________

Description of our experiment.*"To see what would happen if we increased ____________ to _________, we set the following independent variables. Our prediction was that _______________ ____*

Independent Variables (you set these)				Dependent Variables/Outcomes		
Total Number of Moths	Selection	Mutation	Pollution level (%)	Total Light Moths	Total Medium Moths	Total Dark Moths

Interpretation: *This makes sense because…* Or *This was surprising because*

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7. Run as many trials as time permits. For each one, you'll have to set up tables similar to the ones above to record your data. Each time, include predictions and interpretations.

8. **INTERPRETATION OF RESULTS**
    a. Compare this model of peppered moth evolution to the model we used in the first part of this lab. What was better about this model? Worse?
    b. The most important things I learned from this activity were…

Extension
If, like me, you can't get enough of biology, then I recommend you read the Wikipedia article on the peppered moth: it's a great exposition of how complicated the process of science can be. Here's the link: https://en.wikipedia.org/wiki/Peppered_moth_evolution.

Part III. Peppered Moth Netlogo simulation: CONCLUSION

Use *Claim-Evidence-Reasoning* to draw FOUR conclusions about the NetLogo peppered moth simulation activity.

HOW C-E-R works (adapted from www.activatelearning.com)
You start with a question

1) You make a **claim** that responds to the the question, and which makes a statement about the results of an investigation. It answers "what can you conclude?" It describes a relationship between **dependent** and **independent** variables.
2) You provide **evidence** for your claim
3) You provide **reasoning** that ties together the claim and the evidence. You can
    a) Justify why this evidence is important to this claim, or
    b) Includes one or more scientific principles that are important to the claim and the evidence

Sample CER 1: Question: Do cockroaches prefer dark or light environments?

1) **CLAIM**: Cockroaches prefer dark environments
2) **EVIDENCE**: We let 10 cockroaches choose between the shaded and lit sides of a box. 9 of them chose the dark side.
3) **REASONING**: Since more of the cockroaches chose the dark, we can tell that that's what they prefer *(analyzes experimental data)*

Sample CER 2: Question: What frequency of light promotes the most photosynthesis?

1) **CLAIM**: Blue light promotes the most photosynthesis.
2) **EVIDENCE**: Under blue light, plants produced twice as much oxygen as they did when under green, red, or yellow light?
3) **REASONING**: Because chlorophyll is a green pigment, it can't absorb in the green part of the spectrum. Blue light must be the frequency that stimulates chlorophyll the most. *(shows underlying scientific principles)*

Question: *What can we learn from a computer model about how natural selection works?*
Independent Variables: Number of moths; selection; mutation; amount of pollution
Dependent Variables: Number of light, medium, and dark moths

CLASS EXAMPLE: In this case, our claims are *predictions*

1) CLAIM: If we set the **selection** value to the highest value (100) in an environment where the pollution level is 0%, then ….
2) EVIDENCE: ____
   ____
3) REASONING: ____
   ____

As a conclusion to this lab, create at least **FOUR** C-E-R statements that follow the example above. You might have to go back and run the simulation again to do this.