Lesson 1: What types of interactions affect populations of organisms in ecosystems?

Overview:

Purpose:

The purposes of this activity is for students to use a model of a food web describe some of the types of interactions that can occur between organisms and their environment in ecosystems and to describe these interactions in terms of direct or indirect effects and immediate or delayed outcomes.

Prerequisite Student Knowledge:

This unit assumes the following prior knowledge:

- that food is a source of energy and building blocks for all living organisms
- all organisms need food to survive
- plants make their own food from carbon dioxide, water, and sunlight
- animals and decomposers get their food by consuming parts of other organisms.
- organisms can store extra food for later use

The unit does not assume that students have discussed:

- interactions in ecosystems, nor food webs, nor food chains

NGSS Lesson Level Learning Performance:

- Use a model of a food web to describe how a change in the size of a population and/or a change in the resources available in the environment would affect the size of other populations in the ecosystem.

Scientific Principles (re) Discovered in this Activity

- Organisms interact with other organisms and the abiotic surroundings both directly and indirectly in an ecosystem and can result in immediate or delayed effects.

Description of the Lesson

Students observe a photograph two real world ecosystems and describe some of the changes they expect to see in that ecosystem over the course of a week, a month, a year, and 30 years. The class develops a definition for an ecosystem and an interaction. The class builds a physical food web of a pond ecosystem as an entire class using string and index cards. The class uses this model of the ecosystem food web to visualize and predict various forms of interactions between populations, describing indirect and delayed effects on population size as other population sizes and resources necessary for survival change in the ecosystem.

Through discussion, the teacher helps build consensus on types of interactions in ecosystems and indirect vs. direct effects, and immediate vs. delayed outcomes. The class also discusses how using a model of an ecosystem helped them understand, predict, and explain various outcomes.

In their homework students describe what type of objects and interactions they think might be important to include in a computer simulation of an ecosystem, to connect to their upcoming work (throughout the rest of the unit) using computer based models. This homework also helps students understand what it means to use modeling as a scientific practice and models as scientific tools (such as the ecosystem model they made in class).

Lesson Details:

Time 60-90 minutes

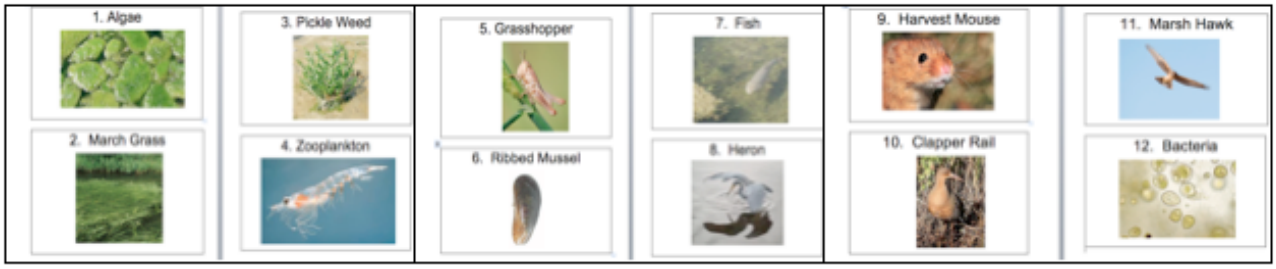
Materials

For Teacher

- Images on step 1.1 (also called Transparency 1.1) and step 1.4 (also called Transparency 1.2
- Projector, document camera, or computer for displaying transparencies / images
- The Driving Question Board – see an example of this in the lesson notes
- An additional piece of butcher/poster paper or space on the wall for students to stick the post it notes on.
- Pieces of tape and 3 large index cards labeled in marker large enough to see across the room:
    - "Prairie Grass" on one, "Mice" on the second, and "Hawks" on the third

For the class activity

- 12 large organisms cards. Full sized versions for printing and cutting out of these are available in the last pages of this teacher guide.



- 1 organisms chart (below) for reference (displayed from WISE or printed up per group).

	Organism	Type	Eats
1	Algae	Producer	Nothing (makes its own food)
2	Marsh grass	Producer	Nothing (makes its own food)
3	Pickle weed	Producer	Nothing (makes its own food)
4	Zooplankton	Herbivore	Algae
5	Grasshopper	Herbivore	Marsh grass
6	Ribbed mussel	Herbivore	Marsh grass
7	Plankton-eating fish	Carnivore	Zooplankton
8	Heron	Carnivore	Ribbed mussel, Plankton-eating fish
9	Harvest Mouse	Omnivore	Grasshopper, Pickle weed
10	Clapper rail (bird)	Omnivore	Grasshopper, Marsh grass
11	Marsh hawk	Carnivore	Harvest mouse, Clapper rail (bird)
12	Bacteria	Decomposer	Dead cells of all organisms

- 50 pieces of yarn each about 10 ft. long (one for each connection in the food web)
- 50 blank index cards (students will draw arrows on these)
- multiple rolls of tape

- 15 markers

For each student

- Modeling Interactions in ecosystems homework – available in pdf form from teacher dashboard web page.

Lesson Outline and Timing

Launch

- Login into WISE and intro the unit through step 1.1 – (5 to 7 min.)
- Student predictions for step 1.2 –(2 min.)
- Building a definition for ecosystems and interactions – (5 to 10 min.)

Explore

- Brainstorm types of interactions in ecosystem (5 min.)
- Demonstrating the type of interactions & lifting/lowering of cards in food chain – (3 to 5 min.)
- Build the class ecosystem model out of string and index cards – (5 to 10 min.)
- Use the model to discuss and predict various interactions in the food web. – (15 to 20 min.)

Summarize

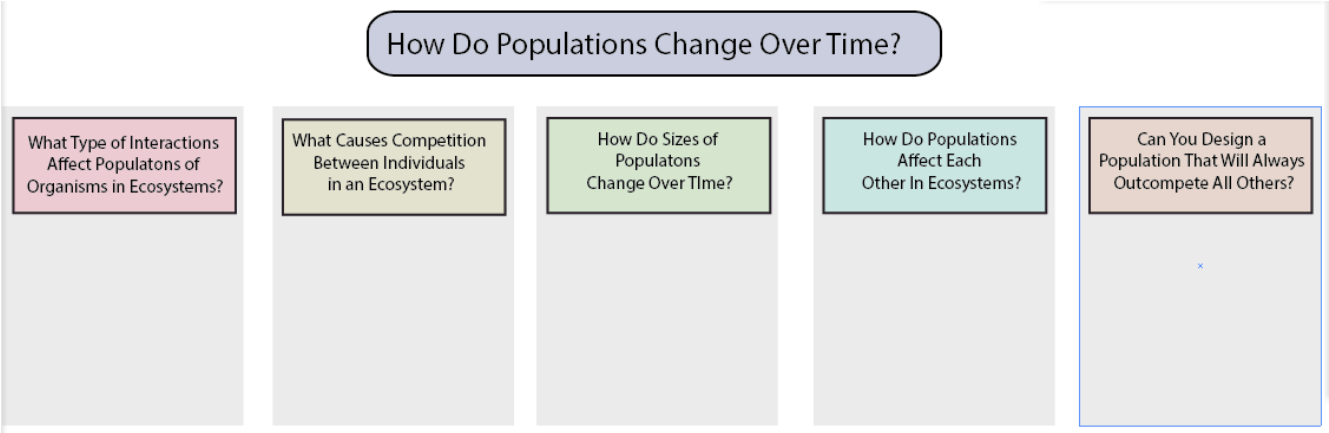
- Student Discoveries and Big ideas – (5 min.)
- Class Consensus Building Discussion – (15 to 20 min.)

Lesson Enactment Details

Build the driving question board below before class starts. Large pieces of butcher paper for each section are recommended. It is typically easiest to use the same driving question board for each class, so when you add your class discoveries to each section, it is recommended you temporarily tape those in. That will allow you to remove them before the next class.

Launch:

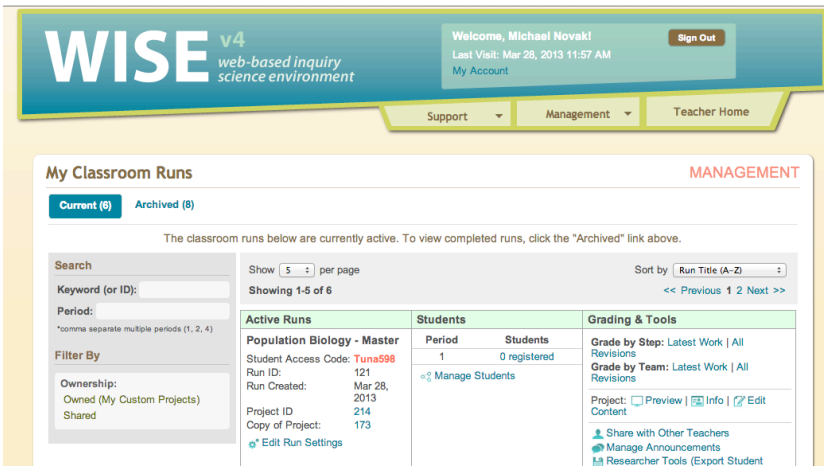
Write the driving question on the board "How do Populations Change?" Under this write five lesson questions you will investigate. Leave space (chart paper) under each lesson question to make bulleted notes about what the class discovers related to each question.



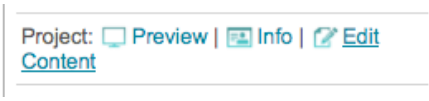
Tell students that you are going to study the driving question over the next two weeks of study. In order to study this question, the class will look at a new lesson question throughout the unit. Tell students that one of the goals by the end of the lesson will be able to answer the lesson question, and the other will be to be able to develop more ideas we can use to answer the driving question. Point out the first question that they will investigate will be "What type of interactions affect populations of organisms in ecosystems?"

- **Have students log into WISE and start the Population Biology Unit.**

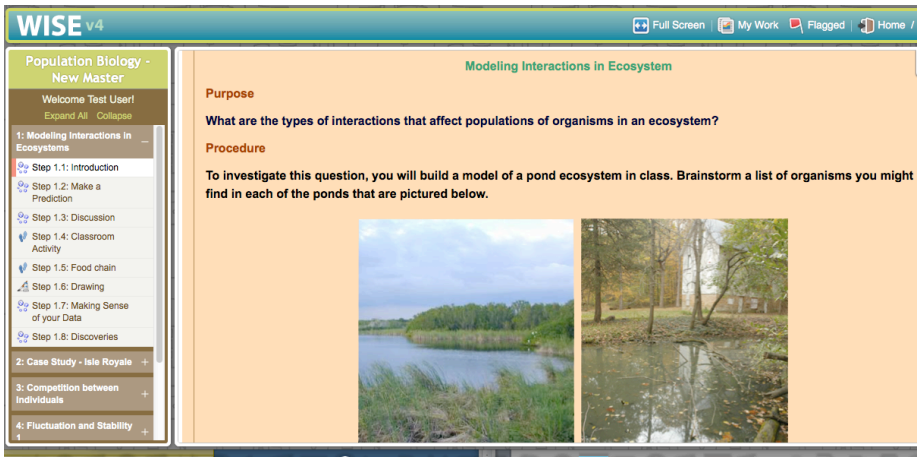
You too will want to log into WISE in teacher mode, but will be projecting some of the images from the student view too. To do this click on the Teacher Home tab. You will see a list of all the active runs you have started for each class period. For the current class that you are teaching. In the example below, the first row show the Student Activity for this Teacher's Period 1 class



Look for the Grading & Tools Column to the right. Under that look for the Project: Preview link. Click on the link that says Preview.



- **Show Step 1.1 Ask students to go to step 1.1 and show this step to students (project it as a transparency or computer projector).**



Tell students that these are two ponds located in different parts of the United States. Besides size, ask them what other things they can infer from the picture that might be different about both ponds. *Students might say depth, what is in the water, what things live around or in the pond, the climate, etc...Again accept all answers that can students can support with reasons or evidence from the photographs.*

Ask students what type of organism they can see in the picture that appears to be interacting with the water of the pond in each picture? Students may mention trees, plants, grasses, etc... Ask whether the same types of plants are interacting with the pond in both? *Accept all answers, asking what evidence would we use/need to support that claim?*

Ask students to brainstorm some of the types of organisms that they don't see in the photograph, but that they might expect to find in the pond (or interacting with the surface of the pond throughout the day or year).

- **Instruct students to complete step 1.1 and then wait a minute before continuing.**

Then have students share some example organisms that might be the same in both ponds. For a couple of their examples, point out the difference between an individual organism and the **population** (e.g. a single trout is an organism and all the trout in the pond is the population).

Ask student if they think the size of the population for these same organisms f(in both ponds) would be the same or different? Ask students whether the size of the population in each pond would always be the same from day to day, month to month and year to year.

Tell students to pick a type of organism that they think lives in, on, or at the edge of one of the ponds and to write that organism in the first question of step 1.2. Tell the students to make some predictions about how the size of the population of that organism would compare from day to day, month to month, and over 30 years.

- **Instruct students to complete step 1.2 and then wait a minute before continuing.**

Tell students that this type of thinking, about what type organisms are in different areas and what type of physical conditions exists in different areas, and how these might change over time is one important way that

scientists think about **ecosystems.**

Ask students if they have heard the word ecosystem before. *Most likely students will say yes.*
Ask students for an example of another type of ecosystem besides a pond. *Students may mention islands, a desert, a forest.*

Write these two ideas under a class definition for ecosystems on the board.

Ecosystems:
-All the living organisms (*biotic*) in that space
-All the non-living (*abiotic)* physical components (air, soil, water, sunlight, etc.) in that space

Return to the questions on the board and point out the word "interact" in today's lesson question "What type of interactions affect populations of organisms in ecosystems?" Tell students that types of **interactions** are what they will investigate further in today's lesson.

Tell students that for any type of organism, there may be many ways it interacts with other organisms or with the environment in that pond. Emphasize that the word interaction can be broken into two parts. "Inter" meaning "between" and "action". To demonstrate this idea, have students take a pencil and draw simple shape on their paper. Ask students for evidence for this claim "pencil acted on the paper". Students *should say the marks on the paper are evidence of this.*

Then ask students evidence they would look for that the "paper also acted on the pencil". *If students don't come with examples of the pencil lead changing size, ask them to observe the tip of the pencil again, and then use the tip of the pencil to scribble on the paper much harder, and then look at the tip again.*

Ask, "What evidence do they now see that the paper acted on the pencil?" *Students should say that an interaction between the paper and the pencil occurred, because the action affected both things. Students may point out that effect on the pencil may have been less noticeable than the affect on the paper.*

Have the class construct a definition for interaction at this point. The class definition should be in the student's own words. Example definitions might include:

Interaction
- Actions between two things
- Effects on both things

Now ask students how studying interactions between organisms would help us understand how populations might be effected in ecosystems. *Accept all answers.*

Say, "It sounds like we should update our ecosystem definition then to also include that studying all the living and non-living things in a space also mean we would be studying how they interact."

Update the class definition for ecosystem to include:

Ecosystems:
-All the organisms in a space (biotic)
-All the non-living physical components (air, soil, water, sunlight, etc.) in that space (abiotic)
-All the interactions between these things

- **Instruct students to complete step 1.3 and then wait a couple minutes before continuing.**

Explore:

- **Have students turn off their monitors and/or turn their chairs to look at the board now. Tell them they will return to their computers in a moment, but don't log off.**

Have students pick one organism from one of the ponds they listed and other students suggest some possible types of interactions that might occur in a pond ecosystem. Have students share types of interactions and keep track of these on the board.

Types of interactions that might occur in a pond ecosystem:	
Between two different individuals:	Between one individual its abiotic (non-living surroundings:

After developing a brainstorming list, tell students that one important interaction that they listed is "which organism eats another organism". If this was listed on the chart, circle where it was listed. If not, ask students where it should be listed. *Students should say under "between two different individuals".*

Prompt students for other types interactions between individuals and their physical surroundings if they haven't listed a few of these. Ask for examples with water, soil, etc... (*You may wish to avoid sunlight, since this is harder to describe in terms of how individuals are affecting the light. If it does come up, then the interaction can be described in terms of how light interacts with matter. In general all matter can absorb, reflect/scatter, or transmit various levels/colors of light. But this idea is not an important prerequisite for students to understand for this unit's learning goals, so only use it if it comes up from students prior knowledge*).

Point out that seeing the relationship between who eats who is sometimes difficult to picture in the entire ecosystem and that one way to visualize this is a food chain of who eats whom. Draw the following the board, using index cards with tape or magnets for each of the populations:

Birds ---> tadpoles-----> algae

Point out that in this food chain, each index card represents the entire population of organisms of that type. In this food chain birds eat only tadpoles, and tadpoles only eat algae, but algae eats nothing because it makes its own food out of carbon dioxide, water, and light. Tell students that relationship between algae and tadpoles is called a predator/prey relationship and the relationship between the tadpoles and algae is a consumer/producer relationship. Draw attention to the fact the arrow shows the direction the food goes in each relationship. Right now this food chain only shows one food source for mice and hawks in this ecosystem.

Ask students to predict what would happen to the size of the tadpole population if most of the algae were removed from the pond ecosystem they live in. Lower the index card for prairie grass to represent this and tell students that lifting the card will represent an increase in population size and lowering it will represent a decrease in population size. So in this example, because the algae decreased you lowered the card. Ask them how the card for the tadpoles should be moved? *Students should say should also go down too. Some students may argue that this won't happen immediately and might not happen if algae back quick enough at a later time. But if the algae population permanently decreased for some reason, it seems like the tadpole population would*

decrease too, due to a lack of food.

Then ask why would this removal of algae also eventually affect the size of the bird population? Why might it take a bit of time before the size of the hawk population is affected*?* *Students should say that the hawk population would decrease too because they had less food.*

Ask students, "How did the model help us visualize possible interactions between populations in the ecosystem?" Accept all answers. Point out that the visualization the model provides, can help us understand if interactions would generate a direct or indirect outcome. For example, a relatively immediate and direct outcome of removing most of the prairie grass is that mice less food available. A more delayed and slightly more indirect outcome of removing the prairie grass is that mice begin to die (after they use up all the food they stored in their bodies as fat). A much more delayed and indirect effect of removing the prairie grass is that hawks would begin to die too (after mice start die off and they have used up the stored in fat in their bodies). Put this thinking in a chart:

Initial Change: Immediately removing the algae		
Effect (or Outcome)	**How direct or indirect?**	**Is the effect immediate or delayed?**
Less food in the ecosystem available for tadpole	Very Direct	Immediate
Some tadpoles die from starvation	More Indirect	Delayed
Less food in the ecosystem for birds	More Indirect	Delayed
Some birds die from starvation	More Indirect	Delayed

Allow students to argue for describing effects in terms of more indirect or more direct instead of simply classifying as one or the other. Allow and encourage students to explain indirect effects in terms of a sequence of multiple "domino effects" of cause and effects.

Teacher Note only: At this point the unit is introducing a way of describing change and effects in terms of direct or more indirect and immediate or more delayed, so that at later points in the unit, when students makes claims such as "the environment causes the population to change." or "the introduction of the invasive species causes the ecosystem to collapse." you can ask them to elaborate with prompts such as "Do you mean directly? Or do you mean indirectly? Do you mean it has an immediate effect or a delayed effect?" And then we can ask students who make claims that the effects are indirect, to provide an explanation of the chain of causes and effects that leads to a particular outcome.

Ask students if they have ever heard of a food web. If this idea is new to students then explain that a food web is similar to a food chain, but it shows all the food sources that all the organisms eat in an ecosystem and helps visualize what actions have direct or indirect effects and have immediate or delayed outcomes. One way to think of a food web is that it represents multiple food chains.

- **Project step 1.4 for students to refer to or have them look at step 1.4 on their own computer as reference for the next hands on activity**

Tell students that they are going to create a model of a food web for a pond ecosystem in Australia shown in step 1.4, but that they are only going to use 12 different types of organisms. Remind them that different pond ecosystem might have more or less types of organisms.

Tell students you will assign 12 groups of people the role of a type of organism in the food web. Assign group members based on proximity. For example in a class of 24 people, assign pairs of people sitting near each the same organism. In a class of 36 people, assign triplets of people sitting near each other the same organism.

Give each group the following supplies:

- One organism card (colored printable cards are in the last pages of this teacher guide).
- Some blank index cards
- Tape and a maker.

- **Have all group members complete steps 1.5 and 1.6 for their organism. They may need to return to step 1.4 to see which arrows they should be drawing.**

Once all groups are done with step 1.6, have the class pause their work on the computer. Tell students their group is in charge of making sure their portion of the food web is correct. They will build their portion of the food web by working together to build the food chain arrows that they drew on step 1.6.

Have one group member take the organism card and arrange a circle of 12 chairs for each organism to sit in. Make sure there is an arms length of space between the chairs. This person sitting in the chair should hold the card. The other group members for that organism are in charge of the following tasks:

- Getting pieces of yarn from the teacher
- Stringing yarn to string to/from their organism. (The person in the chair will hold the end of the string)
- Making sure that there are arrows drawn on index cards and taped to the yarn.
- Checking to make sure the physical model matches what the group drew in step 1.6
- Cleaning up (returning cards and yarns to the materials area at the end of the activity)

In small classes (under 24 students), students not holding the organism cards may have to help multiple organisms with yearn. The 12 seated students can help check to see that all the connections are made between themselves and what they eat and what eats them.

When all the food chains have been strung have all students sit/stand around those seated in circle and have a discussion, simulating various affects on the food web if one population was increased or decreased.

Show this by raising the string bundle or lowering it to represent whether their population size would increase or decrease. Ask each adjoining member of this part of the food chain, to describe whether their population size would go up or go down and why. Again, have them lower or raise their string bundle accordingly. Some example events to simulate are “What would happen to the other populations if the tadpole population size decreased due to disease?” or “What would happen to the other populations if the “Algae population size increased dramatically?”

As each adjoining member of the food web shows how this change would effect their population, ask them if their changes were direct or indirect and they were immediate or delayed and why? Then ask students who are connected to these populations how the newly changed populations (the cards that moved up or down), would in turn affect them. Repeat this. And if time permits, ask what would happen if a population disappeared completely from the food web. Pick any population for this, and have that person drop their card and related strings and again have the adjoining populations explain how this change would affect them. Again repeat for adjoining populations. Then put the population back to its initial state by having students bring their cards and strings back down and ask what would happen if a different population was removed (a predator or a prey).

Repeat the visualization.

Then ask about how changes in the environment might affect the size of a population. If there was very little rain or very little sunlight one year, what population might be affected the most at first? Which ones might be affected indirectly and later through delayed interactions? What if there was a drought that decreased the amount of algae and sedge that could grow in the pond, but did not hurt any animals at first, how could the effects of the drought still affect size of the others populations (even if the effects were delayed or indirect)?

Ask students to summarize why it is difficult to accurately predict the outcome on every population in the food web. Try to focus on the large number of interactions and the delayed aspect of some of the effects or outcomes.

Review with student what we mean by an **effect (or outcome)** by revisiting the lesson question and underline the word affect. "What type of interactions affect populations of organisms in ecosystems?" Say that sometimes when we are how an interaction affects something, we are trying to describe the **mechanism** responsible. Other times we are trying to describe the result of the interaction, in which case we are trying to describe its effect or **outcome**. Tell students that outcomes might be ones that can be measure in the entire population (such as change in the size of the population), a portion of the population, in a single individual, or a non-living part of the environment.

Ask students, how using the food web model helps understand, predict, and explain these outcomes. Ask students for specific examples of how the model helps us do this more easily.

Tell students that we will be using other types of models to help us visualize and simulate outcomes effects in coming days, but that many of these models will be explored on the computer. For those models, students will have to think about interactions, ecosystem, and outcome, just like they did for our yarn and index card model of an ecosystem we made today.

Summarize:

Now have students return to the computers.

- **Instruct students to complete step 1.7 and 1.8 and then wait about 5 minutes before continuing.**

Then have students talk with a partner and select one idea they discovered today related to "What type of interactions occur in ecosystems?" Have students write this idea on a large piece of paper or a large post it note in dark pen/marker. Have one student from each pair of students bring their papers/post-its to the front of the room and stick them up on the board.

Also have students bring up any questions they came up with too to post (the last question on step 1.6 encourages this). Have students post those questions along the side of the driving question board that they think it most related to.

With the papers/post-its displayed for the class to look at together, lead a consensus building discussion. Facilitate the movement and reorganization/clustering of the ideas students brought up, under the 3 headings listed below. This consensus building discussion and reorganization of the student descriptions of their discoveries will help students condense and summarize the big ideas from the day's lesson. If an idea that students suggest doesn't fit under these 3 areas, don't leave it out. Rather, emphasize that the idea shared is another interesting discovery and that the main ideas that the students are responsible for knowing and reusing in future explorations are the ones organized under the 3 areas listed. Try to write the 3 categories in the student's

own words, and using their own papers if possible. You may want to consider posting these big ideas in class, having students summarize these ideas now (or later) in their notes. Either way, try to use the students own words and the way the class expresses the ideas listed below, without feeling it is necessary to use this exact wording. Examples of possible student responses they might contribute on their sheet or post it note are shown in italics. Ask students whether they agree or disagree with how the ideas or organized and whether this summary helps pull out the main points they discovered.

The underlined statement is the suggested category. The non-bold italics statements are possible student ideas. The bold italics statement can serve as another way to summarize what is common amongst the student ideas and each underlined category.

Conclusions & Insights: What Type of Interactions Affect Populations of Organisms In Ecosystems?

- **Interactions between organisms**
  - *Example student idea: An Individual might be eaten by something else.*
  - *Example student idea: Creatures might eat certain things for food in the ecosystem.*
  - ***Summarize with this idea: Organisms can interact with other organisms (through predator/prey, producer/consumer relationships)***

- **Interactions between an organism and its abiotic surroundings**
  - *Example student idea: Animals need water to drink.*
  - *Example student idea: Plants need space for roots to grow.*
  - ***Summarize with this idea: Organisms interact with the non-living surroundings (abiotic) to get the resources they need to survive (water, shelter, space, minerals, etc…)***

- **Interactions can cause indirect or delayed effects on the sizes of populations**
  - *Example student idea: When the size of one population changes it affects other populations next to it in a food chain, but it takes a while.*
  - *Example student idea: Having babies takes time.*
  - *Example student idea: Individuals don't die from starvation right away.*
  - ***Summarize with this idea: Some interactions can cause indirect or delayed effects on the sizes of populations***

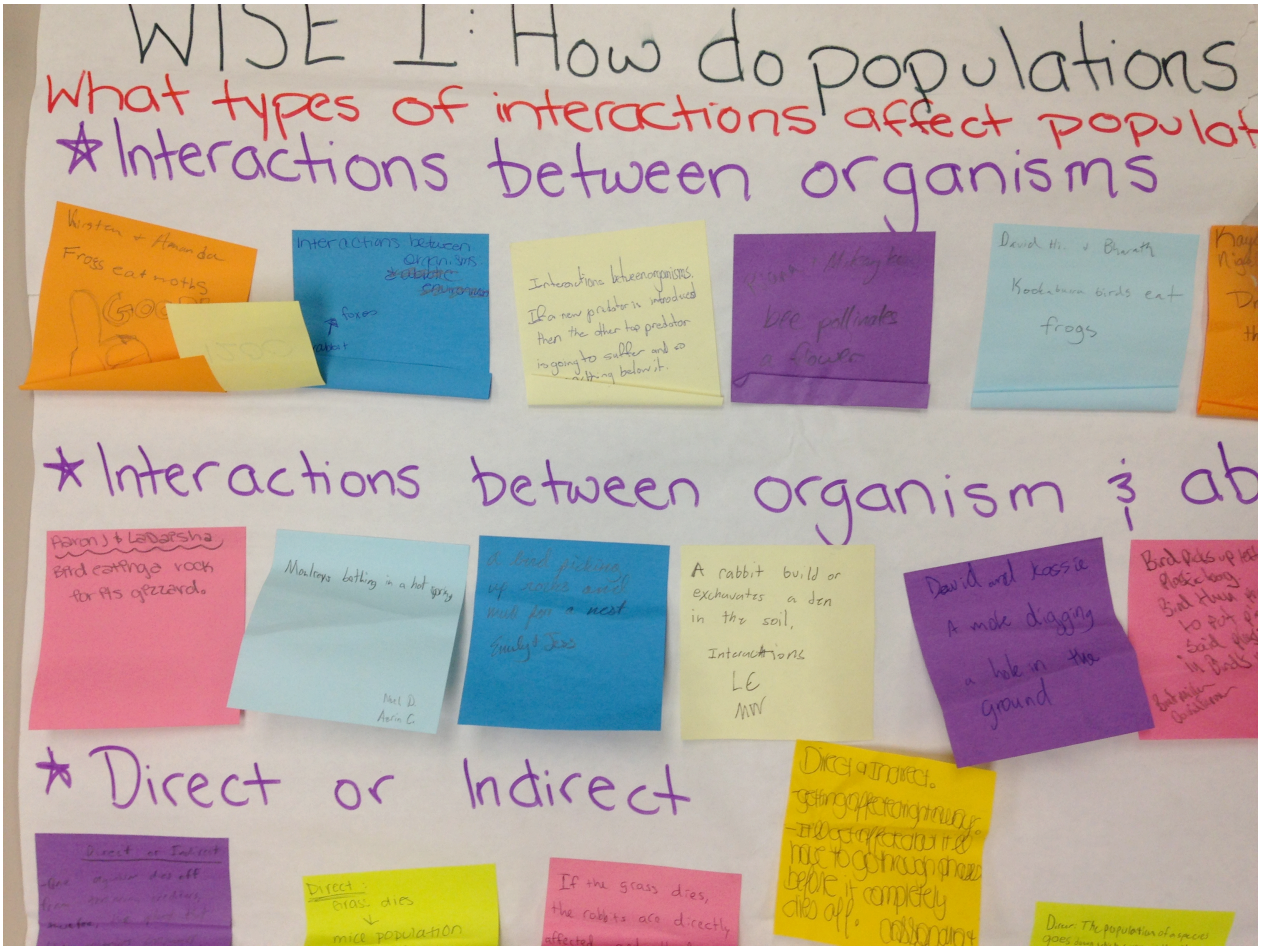
Add only this one scientific principles to the driving question board:

- Organisms interact with other organisms and the abiotic surroundings both directly and indirectly in an ecosystem and can result in immediate or delayed effects.

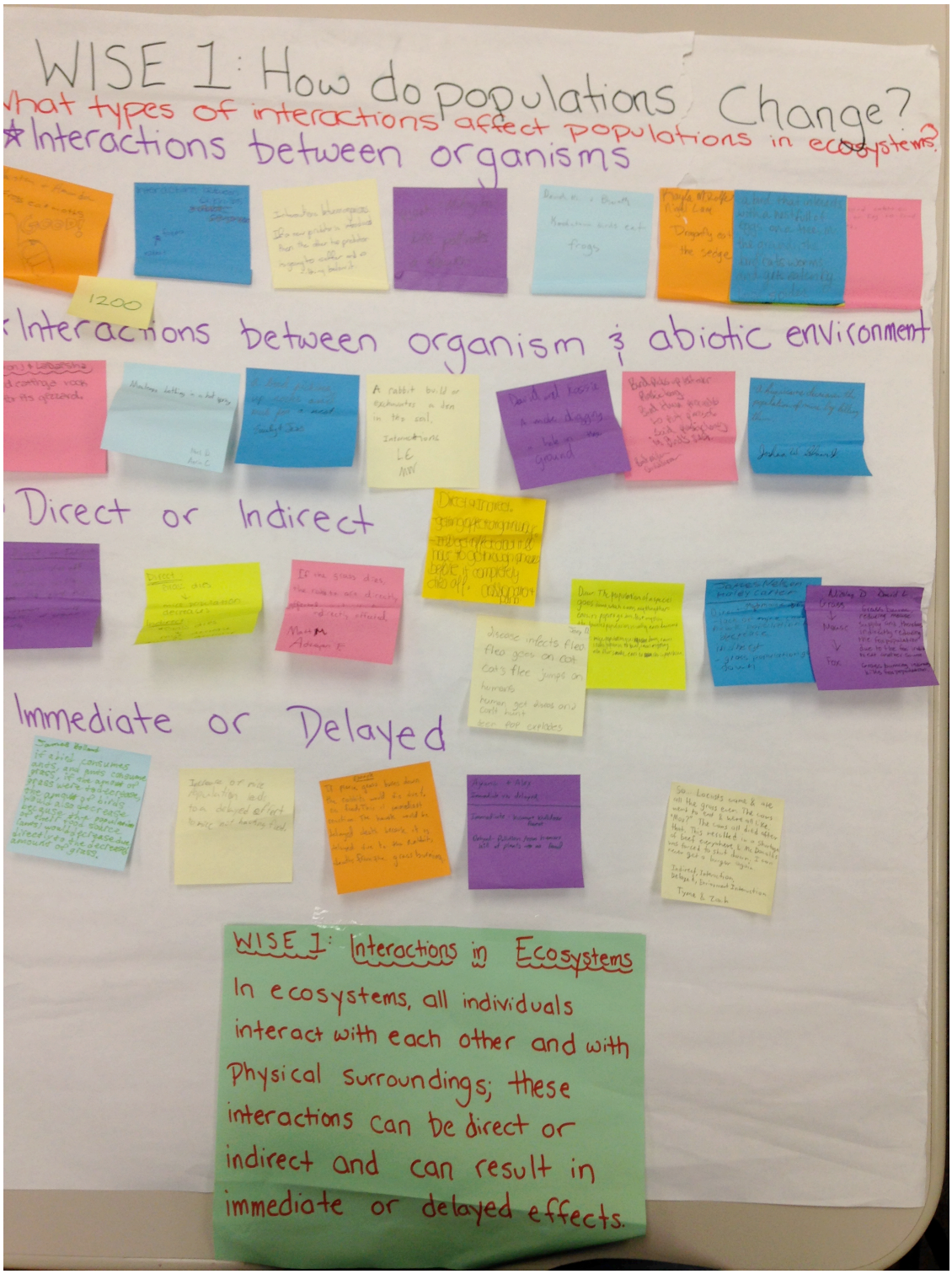
Once these ideas in the bold have been agreed upon by the class make sure they have been added to the blue section of your driving question board. Add them either in the abbreviated form (e.g. "interactions between organisms" or the fuller form of the idea "individuals can interact with each other through predator/prey, producer/consumer, or host/parasite relationships). One easy way to do this is to move the butcher paper or

poster paper that you had been using to keep track of the ideas and tape it under the lesson question for today.

Here are example student post-its from 9th grade regular biology classroom (special thanks to the first pilot teacher: Kate Cook in Dayton, OH):



Notice that the big ideas on the green sheet at the bottom can take a very different syntax and focus than the ones suggested in the teacher manual. This teacher used her own student's ideas and language to craft summaries of their discoveries as they converged on trying to express the scientific principles suggested in the teacher guide



Homework: Assign the homework for this lesson (Reading 1.1). PDFs of the homework are available on the teacher resource page for the unit. Simply click on the blue link for each activity under the student assignments section to download the pdf of the homework.

Teacher Guides | ScreenCast Videos | Student Work Viewer | Student Assignments

Student Assignments for the ModelSim Population Biology Unit

In-class Activity	In-class Steps or handout	Estimated Time	Out of class assignment based on this activity
1: Modeling Interactions In Ecosystems	1.1 to 1.8	60 min.	Reading 1.1 – Interactions In Ecosystems
2: Case Study – Isle Royale	In-class Handout 2.0: Case Study Introduction	60 min.	Homework 2.1 – Case Study Update #1
3: Competition Between Individuals	3.1 to 3.11	60 min.	Reading 3.1 – Competition for Limited Resources
4: Fluctuation and Stability (part 1)	4.1 to 4.11	60-90 min.	Reading 4.1 – Fluctuation and Stability
5: Fluctuation and Stability (part 2)	5.1 to 5.7	40-60 min.	Homework 5.1 – Case Study Update #2 – AND – Reading 5.2 – Environmental Change
6: Competition Between Populations	6.1 to 6.12	60 min.	Reading 6.1 – Competition Between Populations
7: Design a Population	7.1 to 7.9	60-90 min.	Homework 7.1 – Case Study Update #3 – AND – Reading 7.2 – Unchanging vs. Changing Designs
8: Scientific Explanation	In-class Handout 8.0: Case Study Preparing Your Explanation	60 min.	Final Explanation

1. Algae

Image credit: http://en.wikipedia.org/wiki/File:Stigeoclonium_sp_zugespitzte_seitenzweige.jpeg

2. Marsh Grass

Cropped image from: http://upload.wikimedia.org/wikipedia/commons/9/93/Wye_Marsh_panorama1.jpg

3. Pickle Weed

Image credit: http://en.wikipedia.org/wiki/File:Salicornia_europaea_MS_0802.JPG

4. Zooplankton

Image credit: http://en.wikipedia.org/wiki/File:Meganyctiphanes_norvegica2.jpg

5. Grasshopper

Image credit: http://en.wikipedia.org/wiki/File:Young_grasshopper_on_grass_stalk02.jpg

6. Ribbed Mussel

Image credit: http://en.wikipedia.org/wiki/Geukensia_demissa

7. Fish

Image credit: http://upload.wikimedia.org/wikipedia/commons/e/ee/Grass.Carp2web.jpg

8. Heron

Image credit: http://en.wikipedia.org/wiki/File:GBHfish5.jpg

9. Harvest Mouse

Image credit: http://en.wikipedia.org/wiki/File:Micromysminutus1.jpg

10. Clapper Rail

Image credit: http://en.wikipedia.org/wiki/File:R%C3%A2le_gris.jpg

11. Marsh Hawk

Image credit: http://en.wikipedia.org/wiki/File:Northern_Harrier2_by_Dan_Pancamo.jpg

12. Bacteria

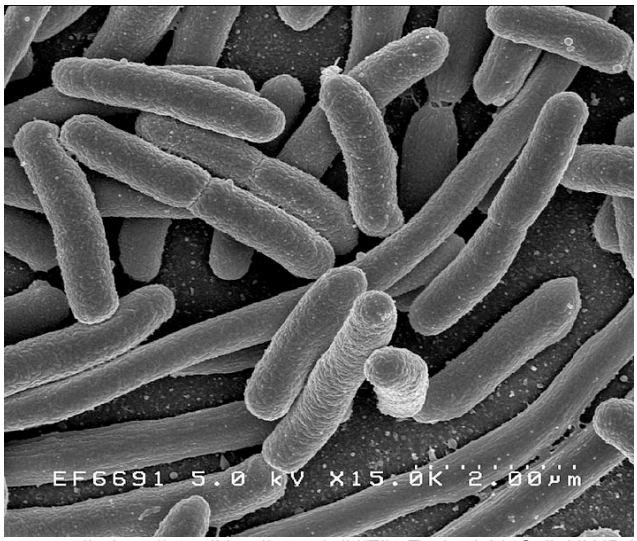


Image credit: http://en.wikipedia.org/wiki/File:EscherichiaColi_NIAID.jpg