Lesson 6: How Do Populations Affect Each Other in Ecosystems?

Overview:

Purpose:

To explain how populations indirectly compete against each other, by applying the concepts of stability and change in population sizes over time, direct and indirect interactions between individuals, and immediate and delayed outcomes in two different ecosystems, each more complex than those modeled previously computer.

Connection to previous activities:

Students have used a computer model to explore the interactions between consumer and producer populations, investigating how temporary disturbances and longer-term environmental change affect both average population size and the fluctuations.

Learning Performances

- Use mathematical and computational representations from student conducted investigations to support explanations of factors that affect carrying capacity of ecosystems. NGSS HS-LS2-1

Scientific Principles Extended in this Activity

- Revised an old principle from previous lesson. The **bold** has been added: More sustained changes in environmental conditions (e.g. loss of habitat**, introduction of predators or invasive species**) tend to change carrying capacities of ecosystems.

Description

Students use the computer model to investigate the interactions between producers and consumers and predators of the consumers, noting the delayed affects between population peaks in each population. They adjust the attributes of all the individuals in one population to see how such changes in that trait affects the carrying capacity and fluctuations of that population. They also introduce an invasive species, adjusting how much it eats, to see how this population affects competition between it and the native consumer (the bugs) They analyze why population fluctuations still exist in both the invasive species and native species for certain conditions and why in other conditions one population disappears.

Through discussion, the teacher helps build consensus about how populations interact with each other, revisiting ideas from activity 1. They discuss how populations affect the stability of each other, revisiting ideas from activity 3, and they describe how populations compete against each other, extending ideas from activity 2 noting that unintentional competition between individuals for the same resources could result in unintentional competition between populations.

In their homework students are introduced to historical examples of where invasive species outcompeted an invasive species and where severe environmental change caused native species to die out in a region or when it prevented an invasive species from entering a new region. They brainstorm some possible changes in the traits of a population that they think might help it outcompete other populations in an ecosystem.

Lesson Details:

Time 60 minutes

Materials

Per Student

- 1 computer with Java 7 and Firefox installed.
- A student WISE account for the class period was already created.
- One small post-it note and one large post-it note.

For Teacher

- 1 computer with Java 7 and Firefox installed and projector or large display screen for the teacher to display the computer model.
- The driving question board
- 1 piece of butcher paper or poster paper or space on the wall for students to stick the post it notes on.

Lesson Outline and Timing

Launch

- Review the interaction diagram for bugs and introduce a parallel one for birds. Discuss predicted causes and effects using the interaction diagrams– (10 min.)

Explore – Exploration 1

- Predict, run, record, and analyze data (step 5.1 to 5.8)– (10 min.)

Explore – Exploration 2

- Predict, run, record, and analyze data (step 5.9 to step 5.13) (10 min.)

Explore – Exploration 3 (Optional – if time is short its ok if student's don't finish this exploration)

- Predict, run, record, and analyze data (step 5.14 to 5.17) (10 min.)

Summarize

- Student complete step 5.18 (3 min.)
- Class Consensus Building Discussion – (17 min.)

Launch:

Ask students to think of the ecosystem they studied yesterday and to identify which population was a producer of food and which was a consumer of food. Students should say the grass was a producer and the bugs were consumers.

Ask students what some types of predators might be of the bugs. Ask them to identify other possible consumers of the plants.

Tell students that they will be investigating how addition of a predator (birds) affect the stability and average carrying capacity of the bug population. Put the interaction model from yesterday on the board again, using index cards for **Deaths** , **Food available per Individual Bug** **, and** **Births**

Label this section of the model, #of BU**GS**

# of BUGS

	immediate affect		delayed affect	down
Deaths	---------->	**Food available per Individual Bug**	---------->	**Births**
	<----------		< ----------	
	delayed affect		immediate affect	

Tell students that in today's computer model, they will be adding a predator and later they will be adding another consumer as an invasive species. The predator they will be adding will be birds. Tell students that the birds will move about the model the same way as bugs do (at the same speeds and with the same blind and random steering). Tell them that the birds will eat any bugs they land on and get energy from those bugs. Just like the bugs, they will reproduce (and split the energy with their offspring) if they have enough energy from food, and they will die if they run out of energy (they lose one energy unit each move just like the bugs did).

On the board, below the first interaction model, put another interaction model, for birds and label it # of BIRDS. A different colored background index card is advised here:

# of BIRDS

up	immediate affect		delayed affect	down
Deaths	---------->	**Food available per Individual Bird**	---------->	**Births**
	<----------		< ----------	
	delayed affect		immediate affect	

Ask students if the # of Birds will be dependent on the # of bugs? Will the # of bugs be dependent on the # of birds?

Then ask students if there is a relationship specifically between bug births and the food available per individual bird. *Students should say yes.* Add a two-direction arrow to show that each of these factors influence each other. Ask and do the same for death of bugs and food available per individual birds. Then ask if the number of birds influences bug deaths. *Students should say yes.* Again add a two-direction arrow between these two factors.

Tell students that these set of interactions represented in the diagram alone shows how one change in one factor could lead to a variety of other changes, some delayed and some immediate, and some direct and some indirect, between the bug and bird populations. But prediction the outcome of such changes becomes difficult as the diagram of interactions become more complex! Tell students that this is where computer models can help us keep track of how these affects add up and cancel each other at different times and under different conditions. Tell them that the model on the board however, makes one thing clearer – it helps us with part of the answer to today's question, “How do populations compete with one another?”

Ask students if there is competition within the bug population? Within the bird population? *Based on their*

experiences from activity 2, students should say that there is some form of unintentional competition occurring in both.

Ask students "what does the diagram tells us about whether the competition occurring in one population affects another the level of competition in another population?" *Students should say that it suggests there may be some sort of interaction related to competition occurring though it may be hard to predict how much or due to what specifically.*

Have students start the explorations for activity 4.

Explore:

Now tell students to read the directions in each exploration of Activity 4, and complete the Data and Observations and Making Sense of Your Data sections for each exploration.

Summarize:

- **Have all students stop the simulations and complete the last step 5.18**

Then after about 3 minutes for this, shift to a discussion. Ask to explain how changes in grass directly affect bugs, and how the changes in bugs also affect the amount of grass growing. Ask them to explain how changes in bugs affect the amount of bird growing and vice versa. Then ask students to explain why changes in grass could have indirect affects on the birds.

Point out that some changes, such as birth and deaths, do not occur immediately as food per individual changes, so the effects of a change in one population can have delayed and indirect affects on other population. This makes the changes that occur over time and the direction of those changes hard to predict.

But, point out that even in the complex interactions between three populations (grass, bugs, and birds), the populations can return to stable values as since when there is a lot of food per individual, the rate of births is higher than the rate of deaths. When there is little food per individual the rate of death is higher than the rate of births. Even between multiple populations these counterbalancing changes contribute to the stability of population sizes over time, since changes in population size affect the amount of food per individual which than affects the population size. For example more births leads to less food per individual, which after some delay than leads to more deaths, which after some delay leads to more food per individual which leads to more births.

Remind students that ….Cyclic change in population size is commonly found when there are feedback effects in a system—as, for example, when a change in any direction gives rise to forces or influences that oppose the change such as changes in population size affecting the amount of food per individual which than affects the population size. For example, more births leads to less food per individual, which after some delay than leads to more deaths, which after some delay leads to more food per individual which leads to more births."

Remind students that this is what they saw in the model yesterday and in the first ecosystems today, "In stable ecosystems, population sizes return to stable states even in the face of some fluctuations and disruptions since as long as some of a population remains, the population can rebound (through reproduction) or collapse (due to insufficient food per individual) back toward the carrying capacity of the ecosystem."

Ask students if when they introduced a predator and when they changed the attribute of the predator, and when they did the same for an invasive species, if they found evidence that the carrying capacity and fluctuations of bug and grass population changed as well. Students should provide evidence from exploration 2 and 3. Summarize this idea from this evidence: "When new populations with different attributes are introduced to an

ecosystem, the interactions in the system may change, and the stability of the system may undergo a radical change until the system achieves a new state of equilibrium with very different conditions, or it may fail to achieve any type of equilibrium."

Ask students to recall what they learned about how unintentionally individuals compete against one another from the 2nd activity. In the case of the invasive species, that population was not directly interacting with the bugs. Instead it was directly interacting with the grass and with the birds. Why then, was this population still competing against the bugs? *Students should say they both were indirectly competing for the same food source and both were indirectly competing for survival from getting eaten by birds.*

Ask students for what values for attributes they found in exploration 3 that led to different outcomes in the competition between the invasive species and the native bugs? Which values of the attributes led to co-survival of both species? Which ones led to many cycles of population fluctuation, but eventual collapse of one population? Which ones led to more immediate collapse or eradication of one of the populations?

Have students talk with a partner and select one idea they discovered that they wrote in the last step (step 5.18). Then have that students write one (or both) of those ideas 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.

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 4 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 4 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 4 areas listed. Try to write the 4 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. Example 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: How Do Populations Affect Each Other in Ecosystems?

Interactions between populations - direct and/or indirect outcomes that are immediate or delayed

- *Example student idea: When one population changes it could affect all the other populations in the food chain or food web.*
- *Example student idea: Some effects occur immediately, others take a while.*
- *Example student idea: Changes in the bird population first affect the bug population and this then later affects the grass population... and vice versa.*
- ***Restate this old idea (and extend it): Some interactions cause an additional chain of interactions that travel further (or later) through the ecosystem. Extension: Every population affects the size of other populations either indirectly or directly, immediately or delayed, through various chains of interactions.***

Competition between populations - Addition of predators

- *Example student idea: The addition of birds affected the carrying capacity for bugs*
- *Example student idea: Adding predators affected the amount of fluctuation in the other populations*
- *Example student idea: Birds and grass don't intentionally compete against each other, but because individual birds are unintentionally competing against each other for food (bugs), this in affects both the bug and grass species.*
- ***Summarize with this idea: When new populations with different traits are introduced to an ecosystem, the stability of the system change until the system achieves a very different state of equilibrium.***

Competition between populations - Introduction of invasive species

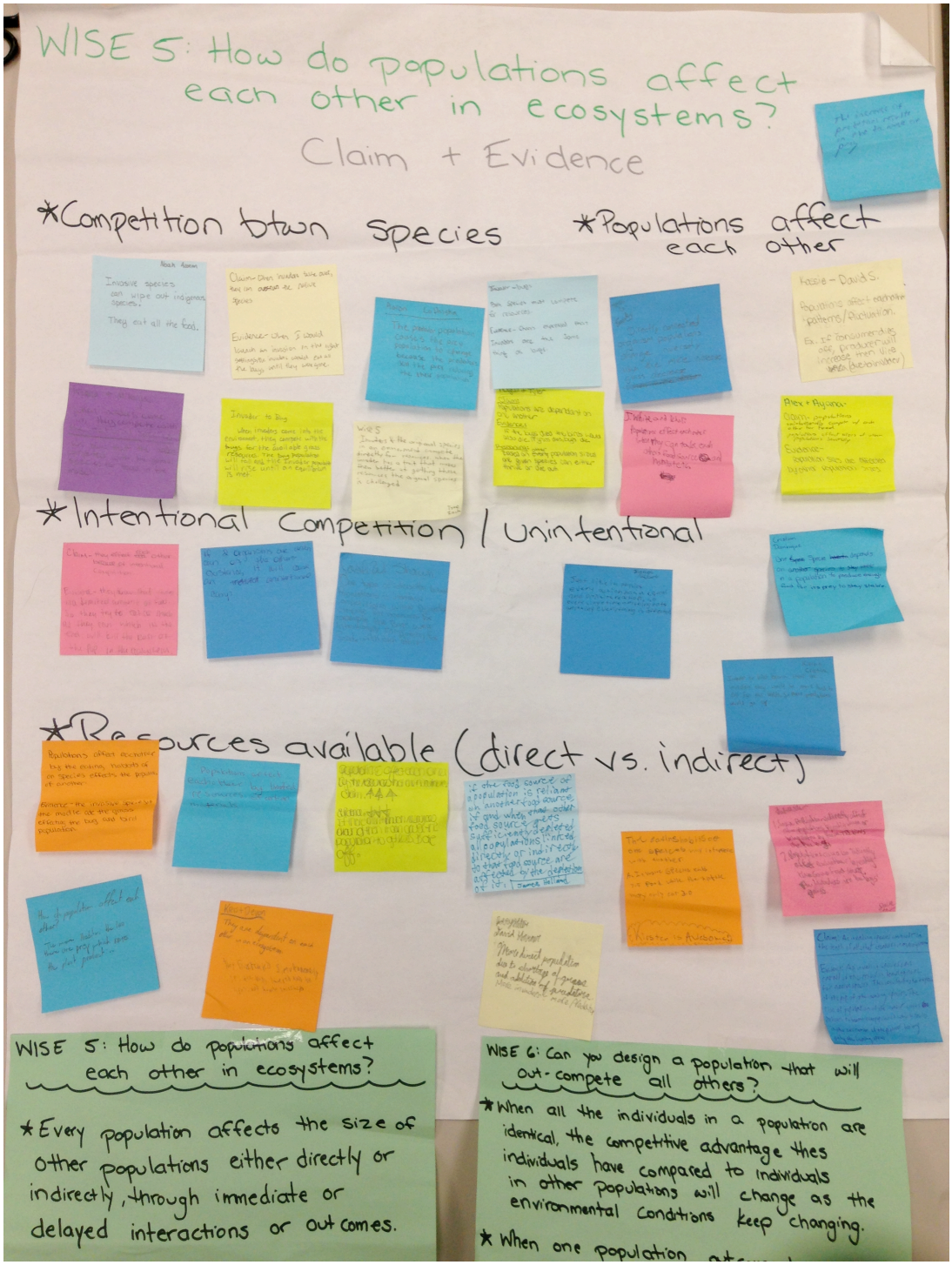
- *Example student idea: Not every organism is equally successful at getting what they need to survive, even when they aren't trying.*
- *Example student idea: Adding the invasive species sometimes affected the bugs and other times the bug population rebounded to previous levels and the invasive species died out.*
- *Example student idea: Adding bugs with low grassland (from previous activities) sometimes led to the bugs dying out, but the grassland returning to previous values.*
- *Example student idea: Sometimes adding a new species causes an existing species to die off.*
- ***Summarize with this idea: Competition between individuals in the same population for one resource, affects competition between individuals in other populations for that same resource.***
- ***Summarize with this idea: When one population outcompetes another, it may lead to immediate or eventual disappearance of other populations in the ecosystem.***

As you can see there a lots of sub-ideas that will come out of this activity. Fold all these ideas above into one scientific principle, by modifying an old one from the previous activity (bold text below are the additions to the old principle).

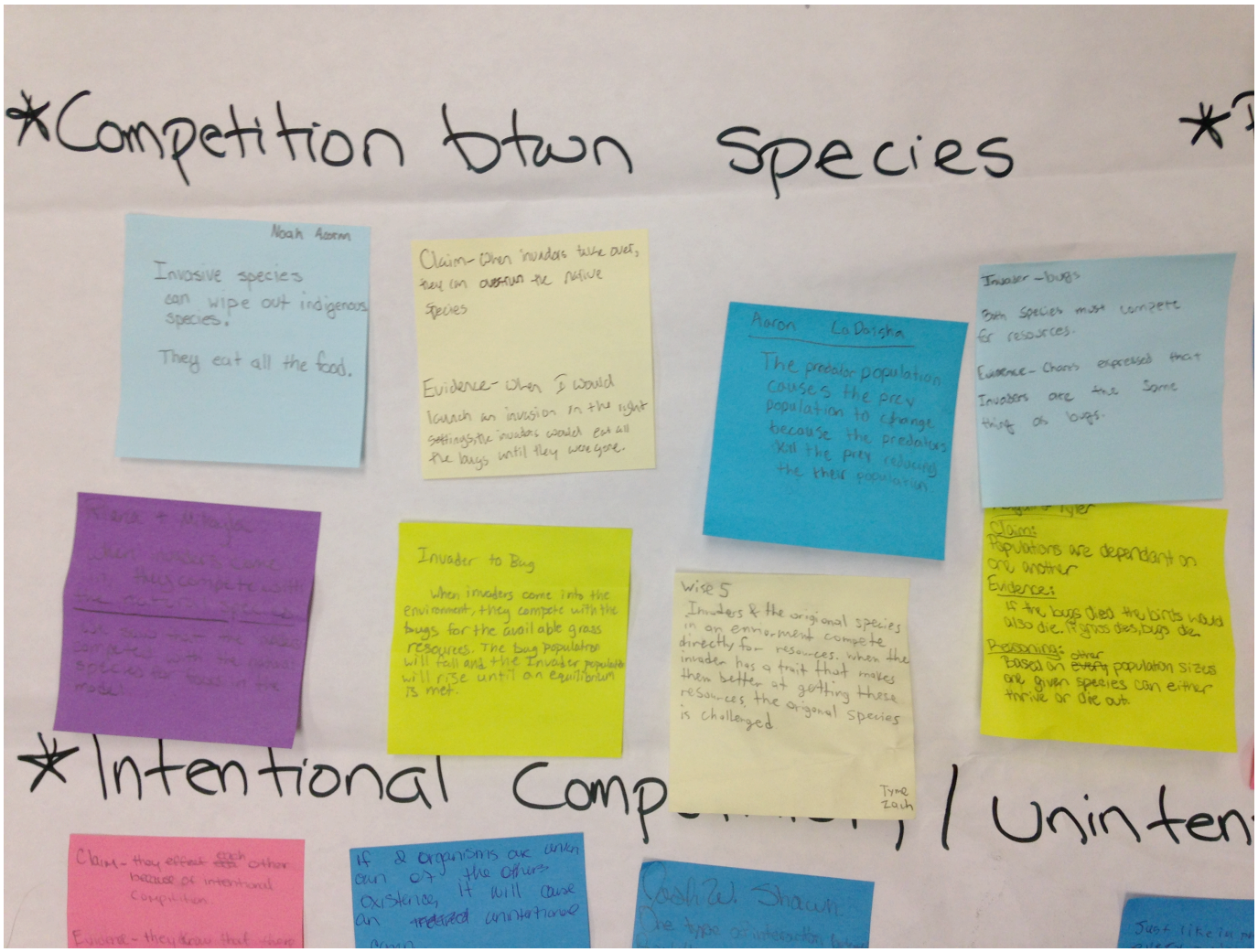
Add this one scientific principle to the driving question board:

- More sustained changes in environmental conditions (e.g. loss of habitat**, introduction of predators or invasive species**) tend to change carrying capacities of ecosystems.

Here are example student post-its from 9th grade regular biology classroom where the teacher kept track of the sub-ideas as well as students contributions (special thanks to the first pilot teacher: Kate Cook in Dayton, OH):



Notice that the big ideas on the green sheet 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


*Competition btwn species
Noah Acorn
Invasive species can wipe out indigenous species!
They eat all the food.
Claim- When invaders take over, they can ~~question~~ the native species
Evidence- When I would launch an invasion in the right settings, the invaders would eat all the bugs until they were gone.
Aaron LaDaisha
The predator population causes the prey population to change because the predators kill the prey reducing the their population
Invader - bugs
Both species must compete for resources.
Evidence- Charts expressed that Invaders are the same thing as bugs.
Invader to Bug
When invaders come into the environment, they compete with the bugs for the available grass resources. The bug population will fall and the Invader population will rise until an equilibrium is met.
Wise 5
Invaders & the original species in an enmorment compete directly for resources. when the invader has a trait that makes them better at getting these resources, the original species is challenged.
Tyme Zach
Claims
Populations are dependant on one another
Evidence:
If the bugs died the birds would also die. If grass dies, bugs die.
Reasoning: ~~other~~ Based on ~~every~~ population sizes one given species can either thrive or die out.
*Intentional Comp / Uninten
Claim- they effect ~~each~~ other because of intentional competition.
If 2 organisms are unable can of the others existence, it will cause an ~~intended~~ unintentional
Just like in

Homework: **Assign the homework (reading 6.1) for tonight.** PDFs of the homework is 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