How to Support Biology Students in Constructing Explanations about Carbon-Transforming Processes

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Goals of the Session

- Share insights from an experienced high school biology teacher about how to support students in **constructing explanations** about phenomena using the crosscutting concepts of energy and matter conservation.

- Share how the *Carbon TIME* curriculum supports students in being more metacognitive, or aware of their own thinking.
  - Using Process Tools to scaffold particular types of discourse
  - Using Process Tools to see how much learning or growth has occurred by the end of a unit

- Q & A at the end of the session

Context of the Collaboration

- large-scale curriculum implementation project
- carbon-transforming processes in socio-ecological systems
- teachers participate for 2 years
- F2F and online PD support
- case study classrooms for more in-depth investigation

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Phenomena in *Carbon TIME*

***Carbon TIME* Units**	
Introductory	Systems and Scale
Organismal	Plants
	Animals
	Decomposers
Large-Scale	Ecosystems
	Human Energy Systems

ethanol burning

animals moving and growing

plants growing

Scientific Practice: Constructing Explanations

supporting students' engagement in 3-dimensional learning

construct explanations about **plants growing** using **conservation of matter and energy**

scientific practice

disciplinary core idea

crosscutting concept

NEXT GENERATION SCIENCE STANDARDS

+ evidence from investigations

Expressing Ideas about Plants Growing

1. Share what your wrote with your shoulder partner.
2. Strategies for getting students to express their ideas and share with a partner.
3. Strategies for sharing as a whole-class.

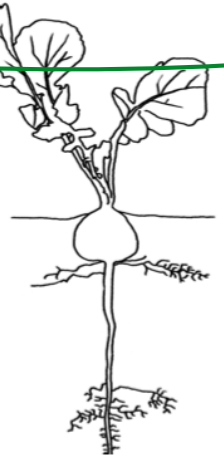
Preparing students to think about movement of matter

Science Practice of Constructing Explanations

Name: _____ Class: _____ Date: _____

1.2 Expressing Ideas Tool: How do *you* think a plant grows, moves, and functions?

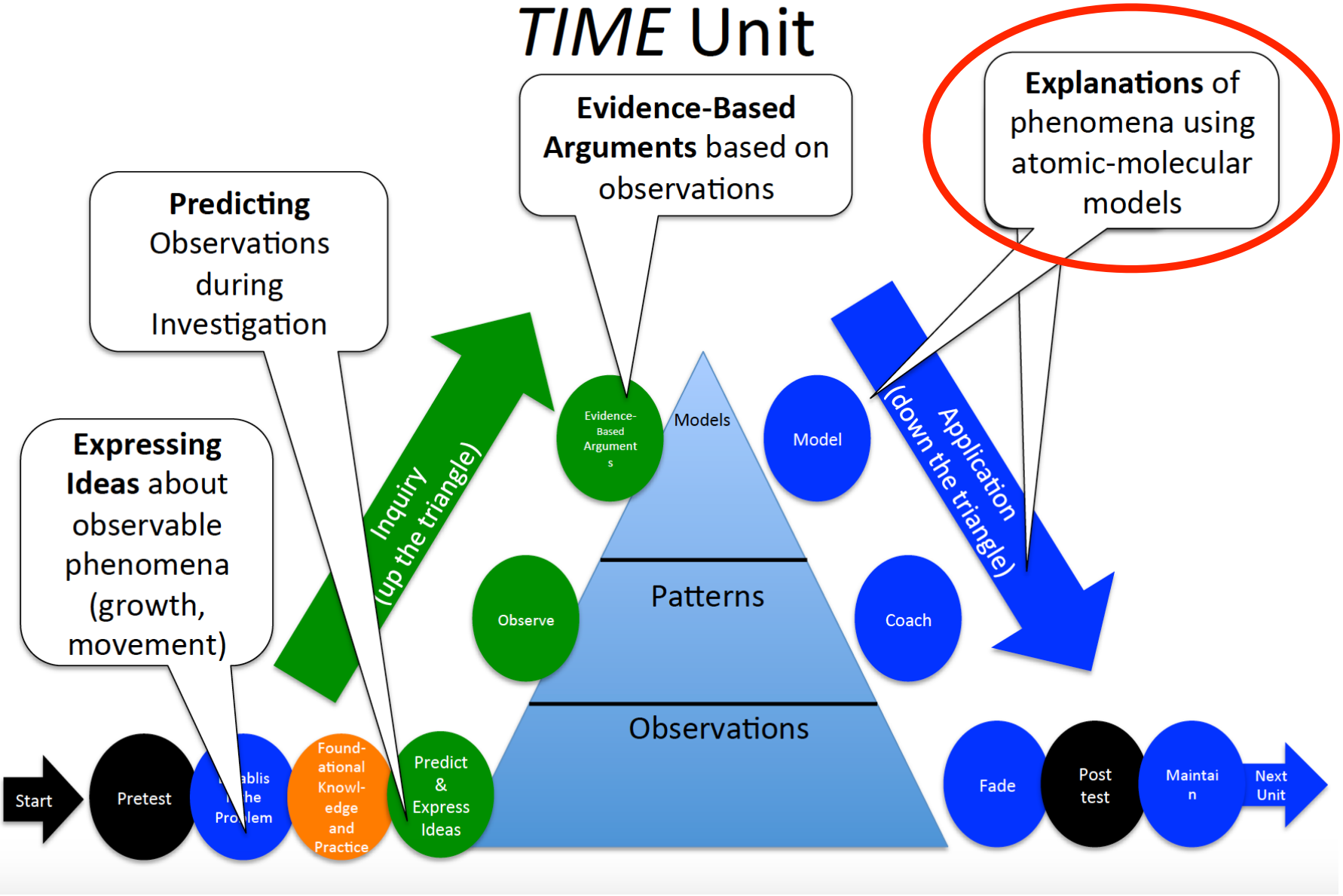
Draw labeled arrows to show your ideas about what might be moving into, out of, or through the radish plant. Think about what materials are moving and how they might be moving.



What goes in: List all the things you can think of that go into the plant.	**What comes out:** List all the things you can think of that come out of the plant.

Your Explanation: Write your explanation for how a plant grows, moves, and functions. Think about what materials and processes you listed in your drawing above.

Core Student Practices in Each *Carbon TIME* Unit

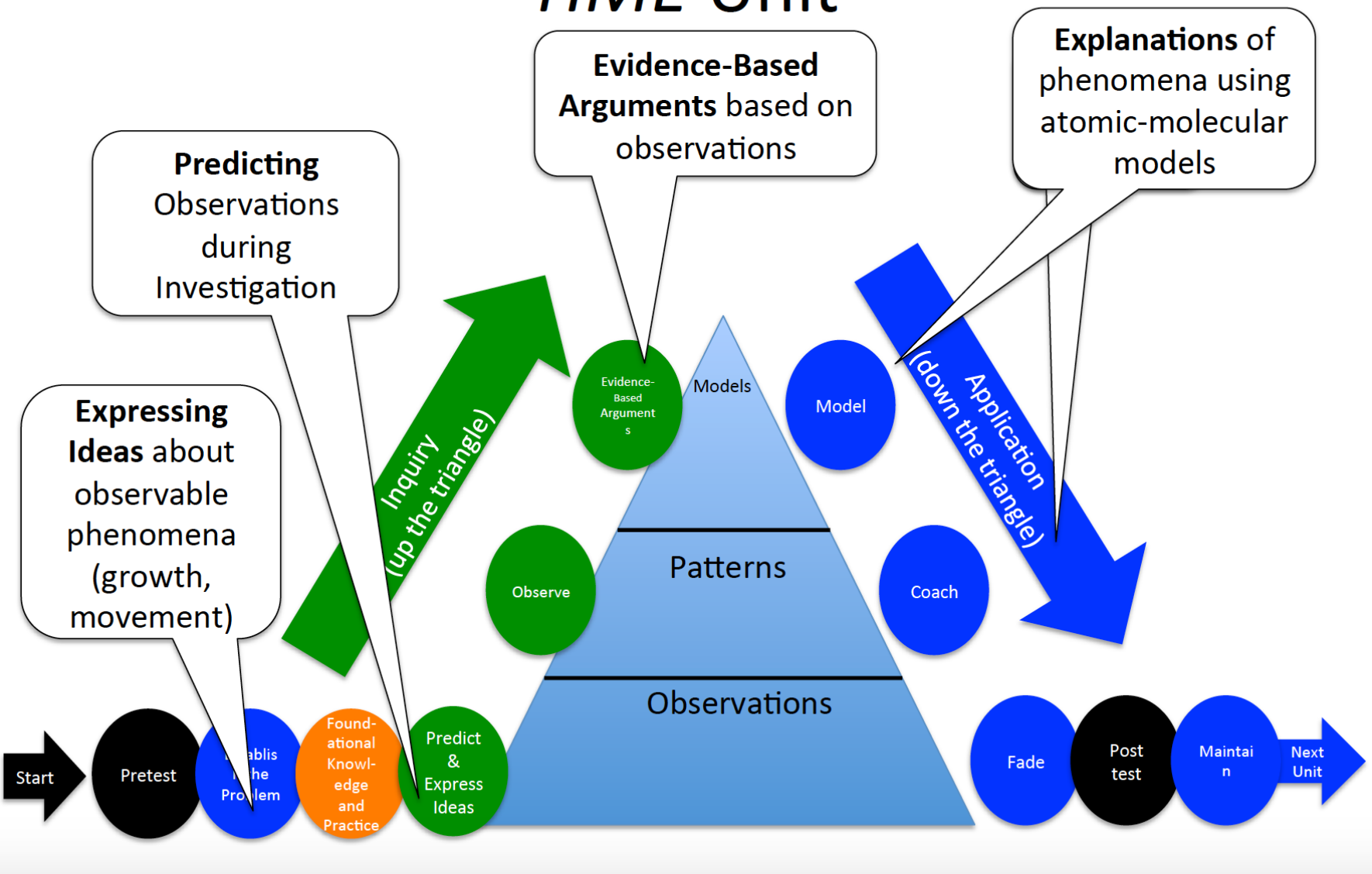


Name: _____ Class: _____ Date: _____

3.1GL Predictions Tool: What do you predict you will observe in your plant investigations?

	Macroscopic scale: *Make predictions about what you will observe.*	Atomic-molecular scale: *Explain your predictions using the Three Questions.*
The Matter Movement Question	**Predictions about mass** How will the movement of matter change the mass of: the plant? | the gel? | everything in the test tube?	Where will the matter in the gel and air move to after one day? *Draw labeled arrows to show how molecules with carbon atoms might be moving into and out of the radish plant as it grows.* 
The Matter Movement Question	**Predictions about changes in BTB** How will matter changes in this system affect CO_2 in the air and the color of the BTB with plants **in the light?** How will matter changes in this system affect CO_2 in the air and the color of the BTB with plants **in the dark?**	What molecules do you think carbon atoms are in the plant before it grows? **Chemical Change** What molecules do you think carbon atoms are in while the plant lives and grows? What other molecules will be involved?
The Energy Change Question	**Predictions about energy** What evidence of energy change will you be able to observe?	What forms of energy do you think are coming into the plant? **Energy Transformation** How does that energy change as the plant lives and grows?

Core Student Practices in Each *Carbon TIME* Unit



Moment of Reflection

What are some takeaways about the challenges of 3D science teaching, and how do we support students in engaging in 3D science learning?

What unanswered questions do you still have?

Evidence from Plants Growing Investigation

Plants in Light and Dark Class Results Poster

Teacher _____ Class Period ___ Date _____

Group	Plants in the Light		Plants in the Dark	
	Start BTB Color	End BTB Color	Start BTB Color	End BTB Color
1	Yellow		Yellow	
	Blue		Blue	
2	Yellow		Yellow	
	Blue		Blue	
3	Yellow		Yellow	
	Blue		Blue	
4	Yellow		Yellow	
	Blue		Blue	

3.5 Evidence-Based Arguments Tool:
What Happens When Plants are in Light & Dark? & What Happens When Plants Grow?

Think about your plant investigations. Complete this tool with patterns from class evidence, conclusions, and unanswered questions.

Class Evidence What patterns did we find in our class evidence about each of the Three Questions?	**Conclusions** What can we conclude about each of the Three Questions using this evidence?	**Unanswered Questions** What do we still need to know in order to answer each of the Three Questions?

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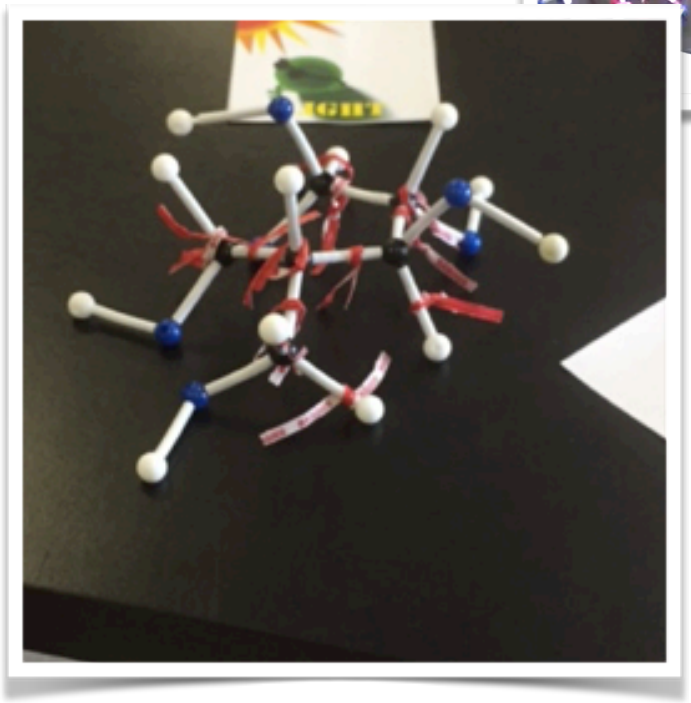
The Matter Change Question			
The Energy Change Question			



Students working with molecular model kits to make connections between observations of macroscopic phenomena and atomic-molecular scales

Connecting atomic-molecular scale with macroscopic observations of phenomenon

Using CCs

C. Atoms last forever! Energy lasts forever!

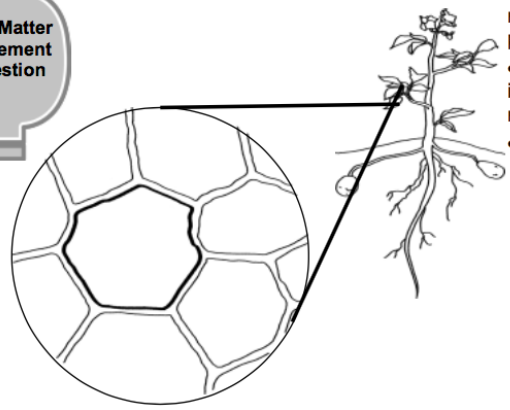
Review the table below to account for all the atoms and types of energy in your models. Then answer the "Check Yourself" questions below the table.

	MATTER			ENERGY	
	How many carbon atoms?	How many oxygen atoms?	How many hydrogen atoms?	How many twist ties?	What forms of energy?
Reactants					
Glucose					
Oxygen					
REACTANTS TOTALS					
Products					
Carbon dioxide					
Water					
PRODUCTS TOTALS					

Name: _____ Class: _____ Date: _____

4.4 Explanations Tool: How does a potato plant make the food it needs to grow and function?

The Matter Movement Question



Draw and label arrows that show molecules moving into, through and out of a **cell** in a potato plant

- Show molecules with carbon atoms moving into and out of the cell in the plant's leaf that makes the food
- Show other relevant molecules

The Matter Change Question

Name the chemical change that allows cells to make food:

Write the chemical equation for this change:

What molecules are carbon atoms in before the chemical change?

What other molecules are needed?

Chemical Change

What molecules are carbon atoms in after the chemical change?

What other molecules are produced?

The Energy Change Question

What forms of energy go into this chemical change?

Energy Transformation

What forms of energy come out of this chemical change?

Explain in words: How does a potato plant make the food it needs to grow and function? (Answer on back).

Use this Explanation Tool to help guide your written explanation, be sure to answer the Three Questions.

Remember: **Atoms last forever** (so you can arrange atoms into new molecules, but can't add or subtract atoms).
Energy lasts forever (so you can change forms of energy, but energy units can't appear or go away).

Quotes from Students

"I think it takes more like, thought to answer those kinds of questions, like A, B, C, or D. Like it's, it kind of gets you more engaged in the test, what you're taking. It's more thinking. Which can be good because then it means that you actually, you really know your information, you know how to piece everything together."

"I just kind of like it [the Explanations Tool] because it's sort of like a sheet where you can get all of your ideas and all of your knowledge on a topic, all onto one page. So it's not just like scattered everywhere like in a bundle. You can look at this and be like, this is how that works, and this is how that works, and how it all kind of works together."

"Animals and plants…they have mitochondria, too… it just works together so well, and then like, you start to question the bigger questions, like the bigger things, like, who set this system up this way? And why do things work this way? And then why do things exist at all, and you know?

"I was just kind of wondering how, like the seed gets the energy to to like, grow, in like… plant, because I think we talked about it for like a bit. Like, originally the radish plant kind of like, put in like a lot of chemical energy into the seed, and that's why it was able to grow, but I don't know. It's, like how there's energy stored in the seed."

Q & A

For more information about *Carbon TIME*:
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Website with free curriculum:
http://carbontime.bscs.org/

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Carbon TIME