Assessing the Coherence Called for in the NRC Framework and NGSS

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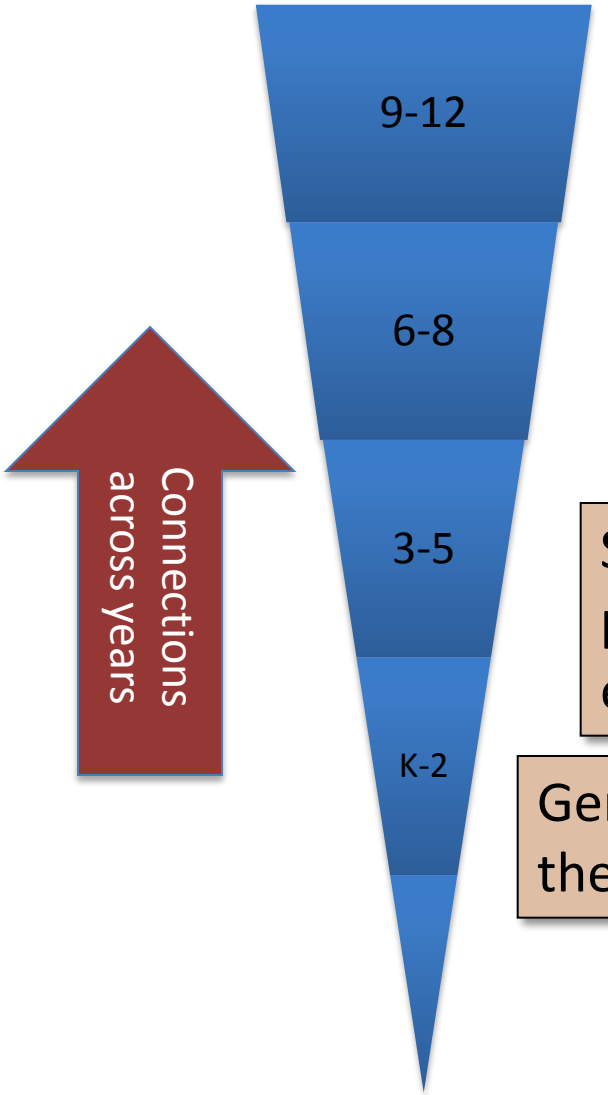
Overview

- Challenge: The Framework organizes learning as a *progression* of ideas and practices
- Example: How to support connections in teaching and learning
- Assessing connections
  - Embedded assessments
  - Summative unit assessments
- Implications for assessment

Building Coherence: Ideas about "food"



Molecular model of biochemical reactions for matter and energy in food.

Chemical reactions model for matter and energy in food, drawing on particle model of matter and energy transfer model.

Simple food model: food consumed or produced is made of matter and provides energy for organisms.

General needs model: Organisms get what they need to survive from the environment.

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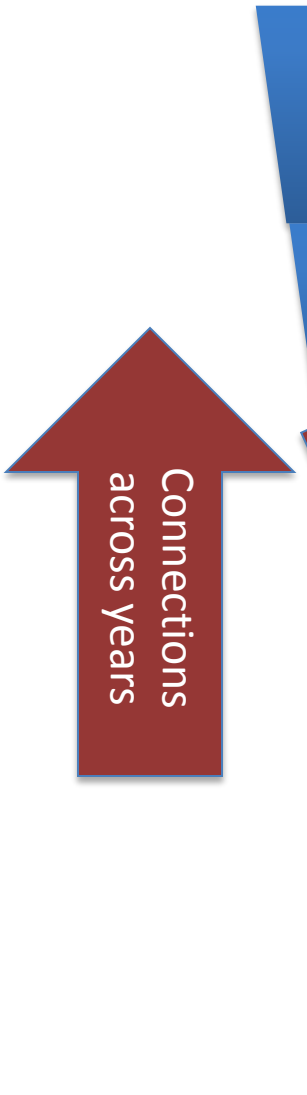

Connections btwn sci strands

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Performance Expectations in NGSS

SCIENTIFIC PRACTICES

MS.LS-MEOE Matter and Energy in Organisms and Ecosystems
Students who demonstrate understanding can:
…
c. Use models to explain the transfer of energy into, out of, and within ecosystems
…

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Use and/or construct models to predict, explain, and/or collect data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs. (c)	**LS1.C: Organization for Matter and Energy Flow in Organisms** ▪ In most animals and plants, oxygen reacts with carbon-containing molecules (sugars) to provide energy and produce carbon-dioxide; anaerobic bacteria achieve their energy needs in other chemical processes that do not need oxygen. (c) **LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** ▪ Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem…	**Systems and System Models-** Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. Models are limited in that they only represent certain aspects of the system under study. (c) **Energy and Matter** Matter is conserved because atoms are conserved in physical and chemical processes. Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

Connections to other topics in this grade-level: **MS.ESS-HE, MS.ESS-ESP, MS.PS-SPM, MS.PS-ECT, MS.PS-CR**
Articulation across grade-levels: **3.SFS, 5.MEE, HS.LS-MEOE, HS.LS-IRE**
Common Core State Standards Connections:

Connections

SCIENTIFIC PRACTICES

SUPPORTING CONNECTIONS

Driving question

What is going on inside our bodies that helps us get energy to do the things we do?

(from NSF-funded middle school materials, published 2012)

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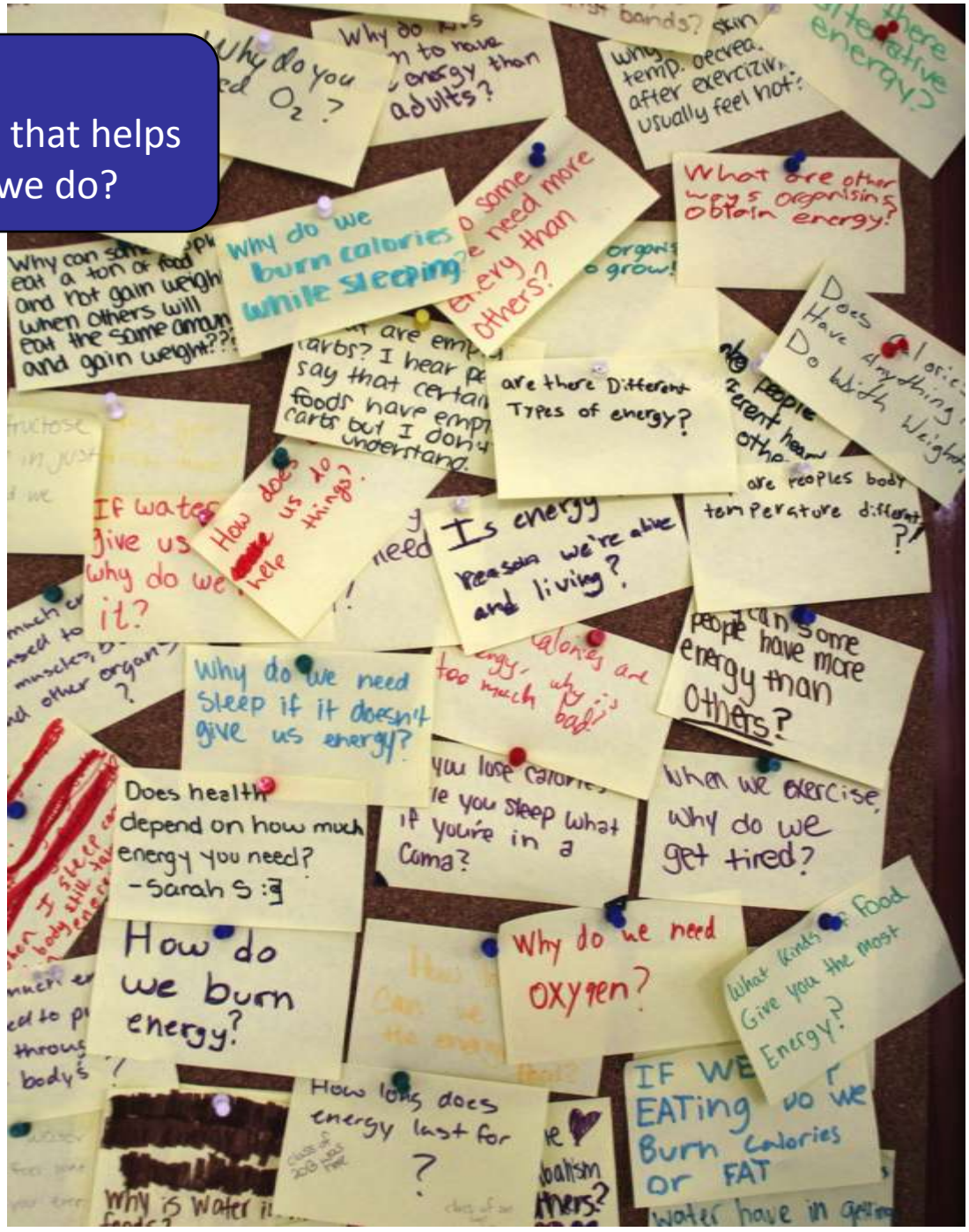

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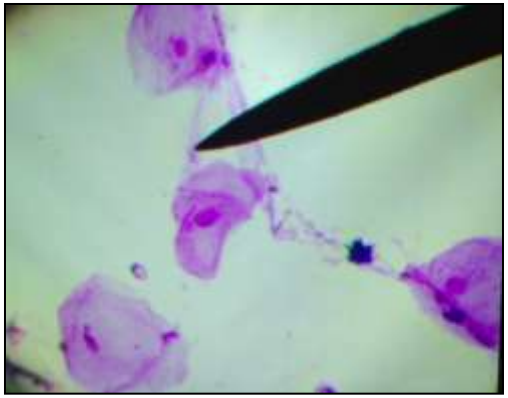

Questions	Investigations	Explanations
What is my body made of?	Microscope investigations	We are made out of cells.

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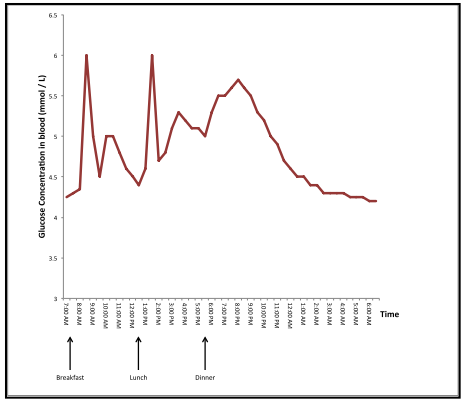

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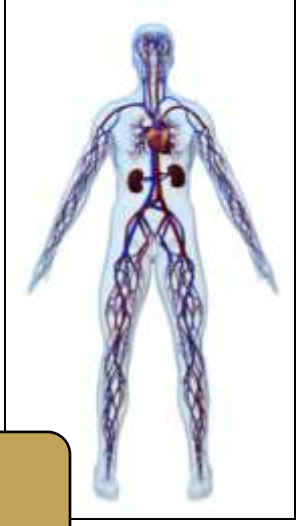

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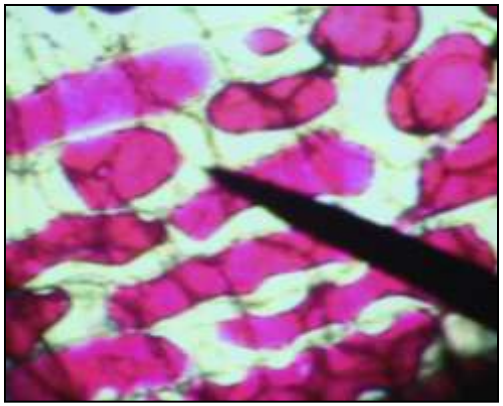

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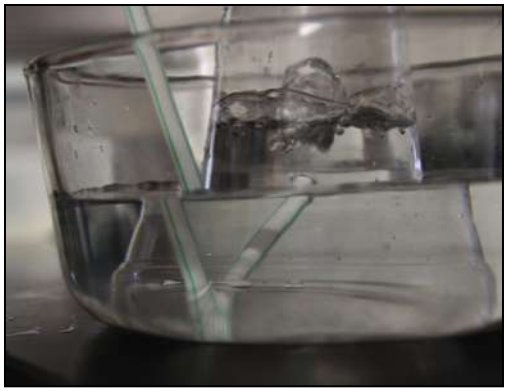
Can cells actually use the glucose?	Use of glucose by yeast	Cells use glucose, produce waste, for growth and energy



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Where is the oxygen going?	Lower O_2 in exhaled air	Oxygen used in chemical reaction to release energy from food

Building on Prior Knowledge

Prior Core Idea	Source	How Students Build on The Understanding
Food provides living things with building materials and energy. (Ecosystems)	6th bio	*Using food somehow gets matter to be used in growth and energy to be used for body functions.*
All matter is made of particles; matter cannot be created or destroyed. (Nature of Matter)	6th chem	*The increased mass in growth must come from somewhere, so it must be from the food input to the body.*
Energy cannot be created or destroyed, but can be transferred from one part of a system to another, converted from one form to another. (Energy)	7th phys	*The only way for the body to get energy is to get it from somewhere else, either transfer or conversion of energy.*
Chemical reactions can rearrange matter into different combinations, changing its properties. (Chemical Reactions)	7th chem	*To use the mass in food, a chemical reaction must be taking place to rearrange the substances.*
Chemical reactions can convert energy from stored energy to other forms of energy. (Chemical Reactions)	7th chem	*There must be a chemical reaction going on to get the stored energy in the food into a form usable by the body.*
One type of chemical reaction that can convert stored energy to other forms is when some substances combine with oxygen in burning. (Chemical Reactions)	7th chem	*The oxygen that is shipped around the body along with food must be being used in a chemical reaction to convert stored energy in the food molecules.*

Performance Expectation Tapping Into These Connections

Construct and argue for an explanation for why the air a human breathes out contains a lower proportion of oxygen than the air he or she breathed in. Address where in the body the oxygen was used and how it was used.

SCIENTIFIC PRACTICES

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Construct explanations and design solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

Engaging in Argument from Evidence

Construct a convincing argument that supports or refutes claims for explanations or solutions about the natural and designed world. Use oral and written arguments supported by empirical evidence and reasoning to support or refute an argument for a phenomenon or a solution to a problem.

Disciplinary Core Ideas

LS1.C: Organization for Matter and Energy Flow in Organisms

- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth or to release energy.
- In most animals and plants, oxygen reacts with carbon-containing molecules (sugars) to provide energy and produce carbon-dioxide; anaerobic bacteria achieve their energy needs in other chemical processes that do not need oxygen.

Crosscutting Concepts

Energy and Matter

- Matter is conserved because atoms are conserved in physical and chemical processes. Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.

Embedded Assessment

SCIENTIFIC PRACTICES

Solving the Mystery

Inspector Bio wants to know what you have figured out about the oxygen that is missing from the air you exhale. Explain to him where the oxygen goes, what uses it, and why. Write a scientific explanation with a claim, sufficient evidence, and reasoning.

Where Does Oxygen Go in the Body, What Uses it, and Why?

"After being inhaled, oxygen goes through the respiratory system, then the circulation system or blood, and goes throughout the body to all the cells. Oxygen is used to burn the food the body needs and get energy for the cells for the body to use. For anything to burn, it must have energy and oxygen. To then get the potential energy in food, the body needs oxygen, because it is a reactant. When we burned the cashew, the water above it increased, giving it thermal energy and heating it up. Therefore, food is burned with oxygen to get energy."

Where Does Oxygen Go in the Body, What Uses it, and W[illegible]

Argument from evidence

Disciplinary Ideas from Physical Sci

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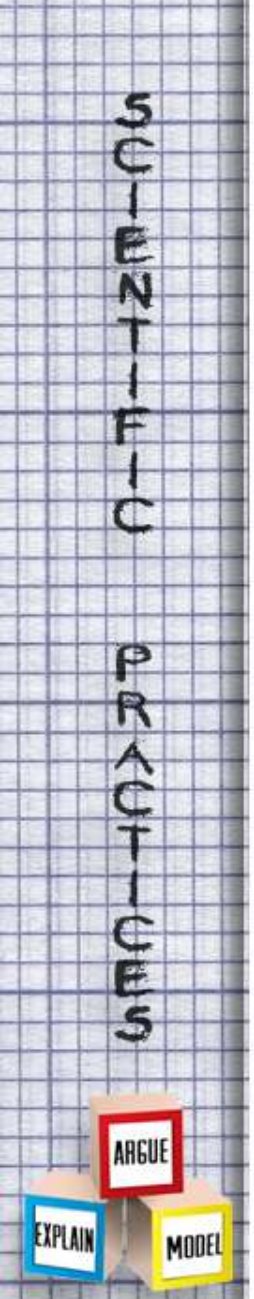
Life Science Disciplinary ideas

SCIENTIFIC PRACTICES

Rubric that looks for connections

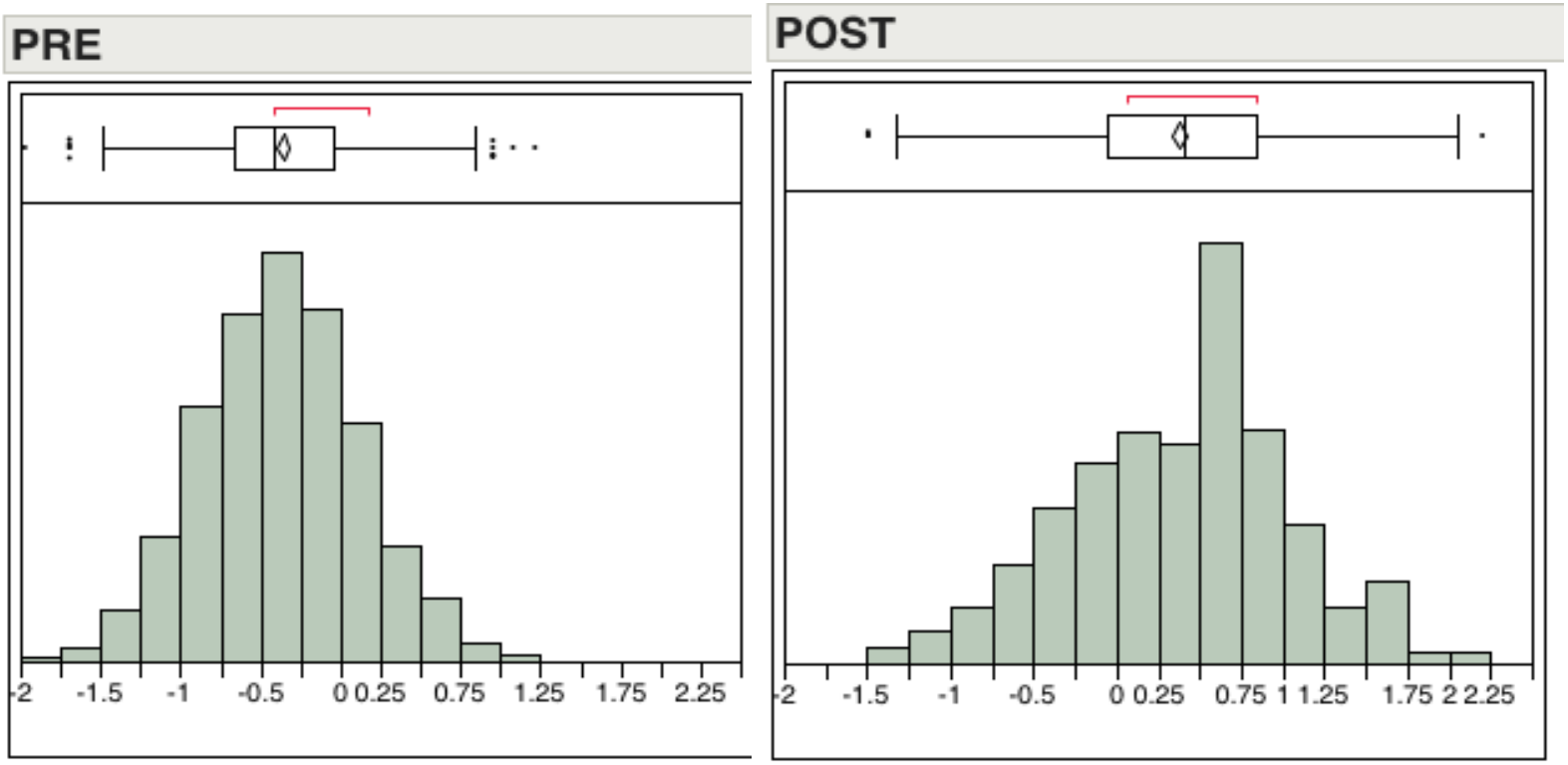
Construct an explanation for where oxygen goes in the body and how it is used.

Where does the oxygen go?	
Where is oxygen used for? *(Using physical science ideas in the argument)*	
3	Full account using physical science ideas – oxygen is used in a chemical reaction with food that includes a conversion of the stored energy in food to forms usable by the cells
2	Oxygen used in a chemical reaction (or “burning”) to get energy, but incomplete matter and energy physical science story (e.g., “burns the oxygen” without mentioning food or glucose, or “react with glucose” but no account of energy)
1	Oxygen used to get energy, or used with food for energy; no physical science mechanism presented to get energy
0	Missing or generic survival (e.g., to breathe, for living)



Pretest / Posttest Unit Assessment

SCIENTIFIC PRACTICES



13 MC + 5 CR items: matter and energy in human body

N = 831 students (9 teachers, 5 states)

Pre average Ability score = -0.36

Post average Ability score = 0.38

Effect size (pre vs. post) = 1.53

Implications

- Goals of NRC Framework & NGSS require focusing on connections in learning
  - Core disciplinary explanatory ideas
  - Practices of argumentation, developing models, constructing explanations
- Making connections explicit and meaningful challenge (a) how we represent and (b) assess standards
  - Unpacking Life sci standard requires drawing on meaning from physical science standards it builds on
  - Assessments need to track applying knowledge from one learning context in new context – need to follow these paths to construct assessment criteria
  - Need to guard against superficial application – e.g., asserting that processing food involves "a chemical reaction" vs. using idea of chemical reactions as a tool in an argument to explain phenomena