

# Conceptual Mapping to Facilitate Review of State Science Standards

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# Questions

- What do we mean by “conceptual maps?”
- How do strand maps differ from concept maps?
- Why did we use strand maps to assist the science standards review process of Massachusetts?
- What patterns emerged from the strand maps?
- How do we envision application of strand and concept maps?

# What do we mean by “conceptual maps?”

Conceptual maps show linkages among conceptual content.

- Conceptual content is written in bubbles.
- Arrows link the conceptual content.

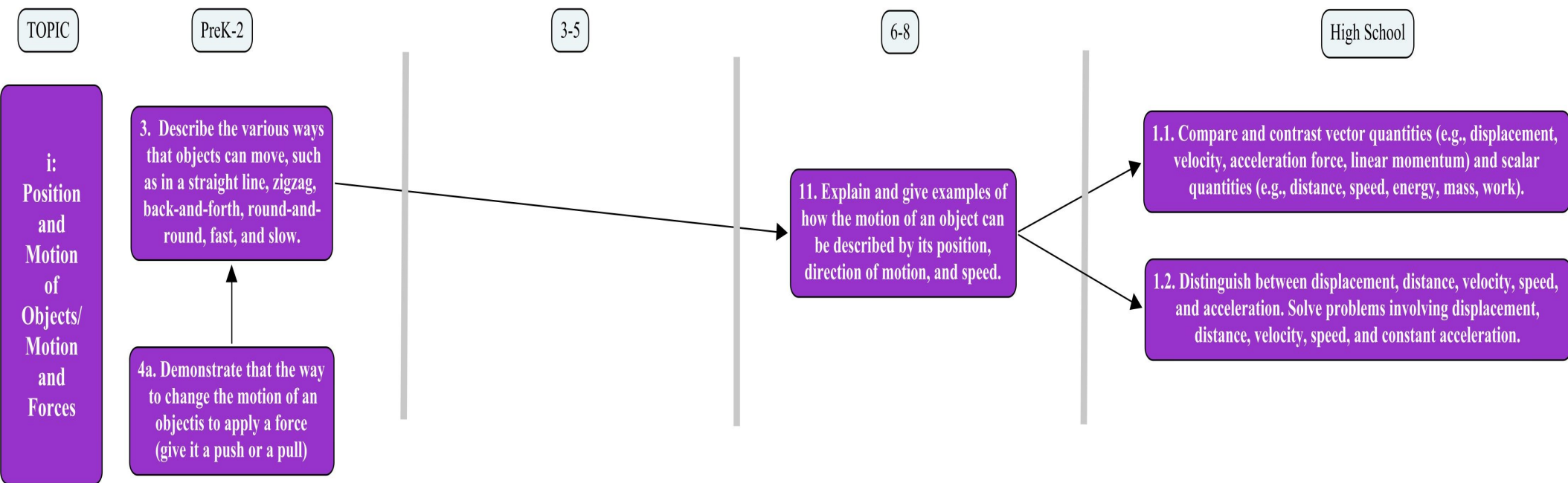
Strand maps and concept maps both fulfill these criteria.

# How do strand maps differ from concept maps?

- Quantity of conceptual content
- Meaning of linking arrows
- Linkage to additional digital resources

# Portion of Physical Science Strand Map: Force and Motion Progression

**Figure 1.** Portion of the Physical Science strand map showing several *force and motion* standards (From *Strand Maps of the 2001/2006 Science and Technology/Engineering Standards* <http://www.doe.mass.edu/omste/maps/>)



# Why did we use strand maps to assist the science standards review process of Massachusetts?

## Frameworks Image



### Massachusetts Science and Technology/Engineering Curriculum Framework

October 2006

*Pre-Kindergarten–High School Standards  
as adopted by the Board of Education in 2001 (PreK–8) and 2006 (High School)  
and  
Updated Resources*

Massachusetts Department of Education  
350 Main Street, Malden, MA 02148  
781-338-3000 [www.doe.mass.edu](http://www.doe.mass.edu)

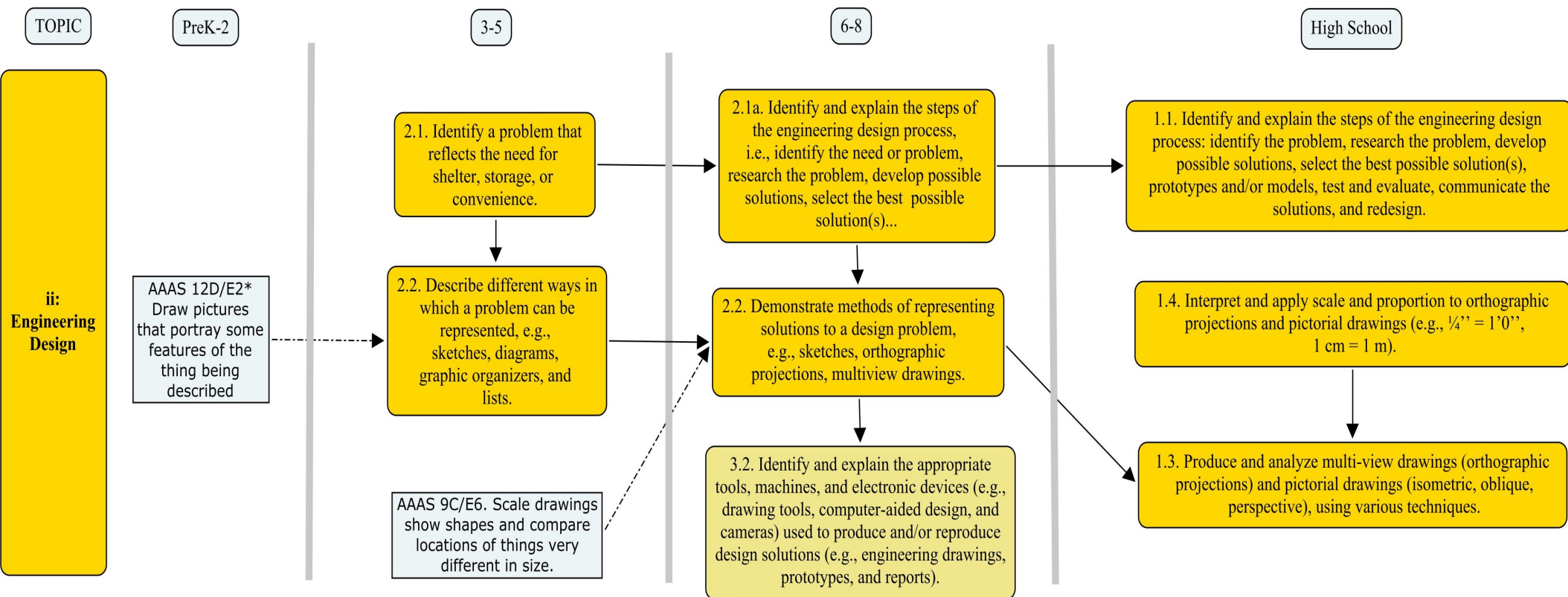
## AAAS Maps Image



# What patterns emerged from the Strand Maps?

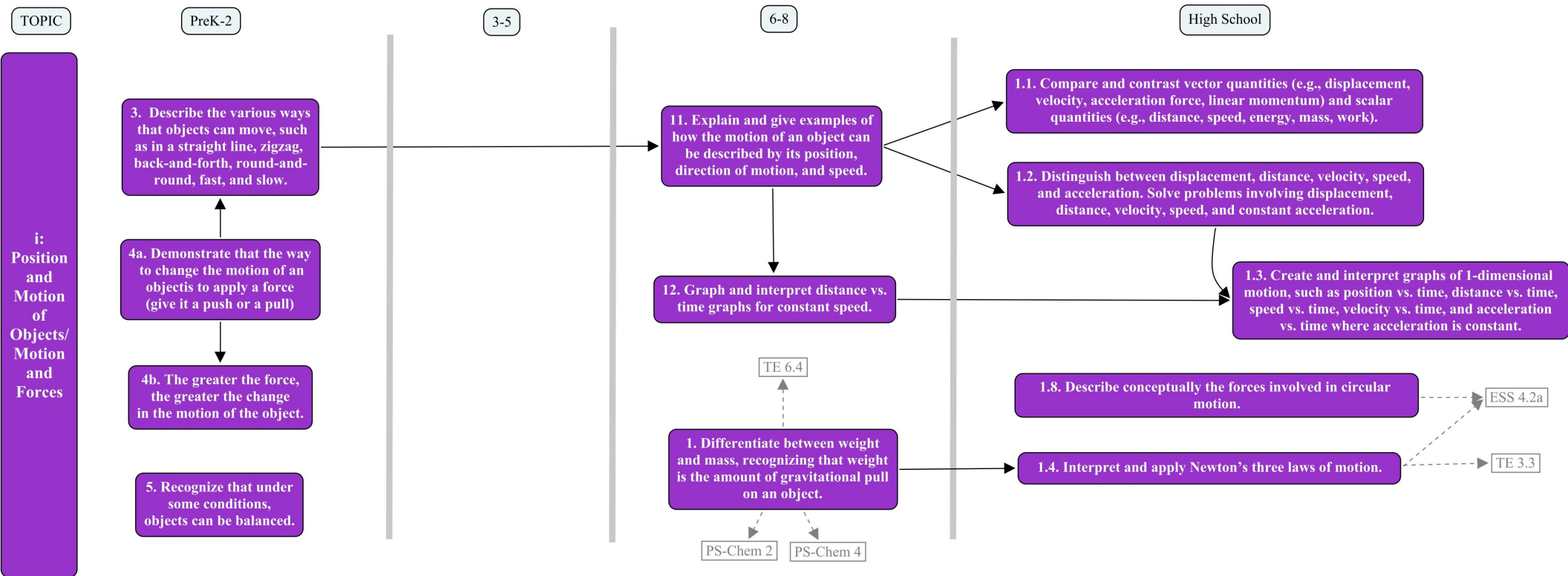
- Patterns that would prove useful to the science curriculum review process: identification of unsupported standards
- Patterns that demonstrated aspects of Ausubelian Learning Theory

# Missing Foundational Standards





# Opportunity-to-Learn Gaps & Isolated Concepts



# Diverging Standards

TOPIC

PreK-2

3-5

6-8

High School

iv:  
Anatomy  
and  
Physiology

PS-Chem 6. Differentiate between an atom (the smallest unit of an element that maintains the characteristics of that element) and a molecule (the smallest unit of a compound that maintains the characteristics of that compound).

5. Describe the hierarchical organization of multicellular organisms from cells to tissues to organs to systems to organisms.

6a. Identify the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, excretion, protection from disease, and movement, control, and coordination).

4.1a. Explain generally how the digestive system (mouth, pharynx, esophagus, stomach, small and large intestines, rectum) converts macromolecules from food into smaller molecules.

4.3. Explain how the respiratory system (nose, pharynx, larynx, trachea, lungs, alveoli) provides exchange of oxygen and carbon dioxide.

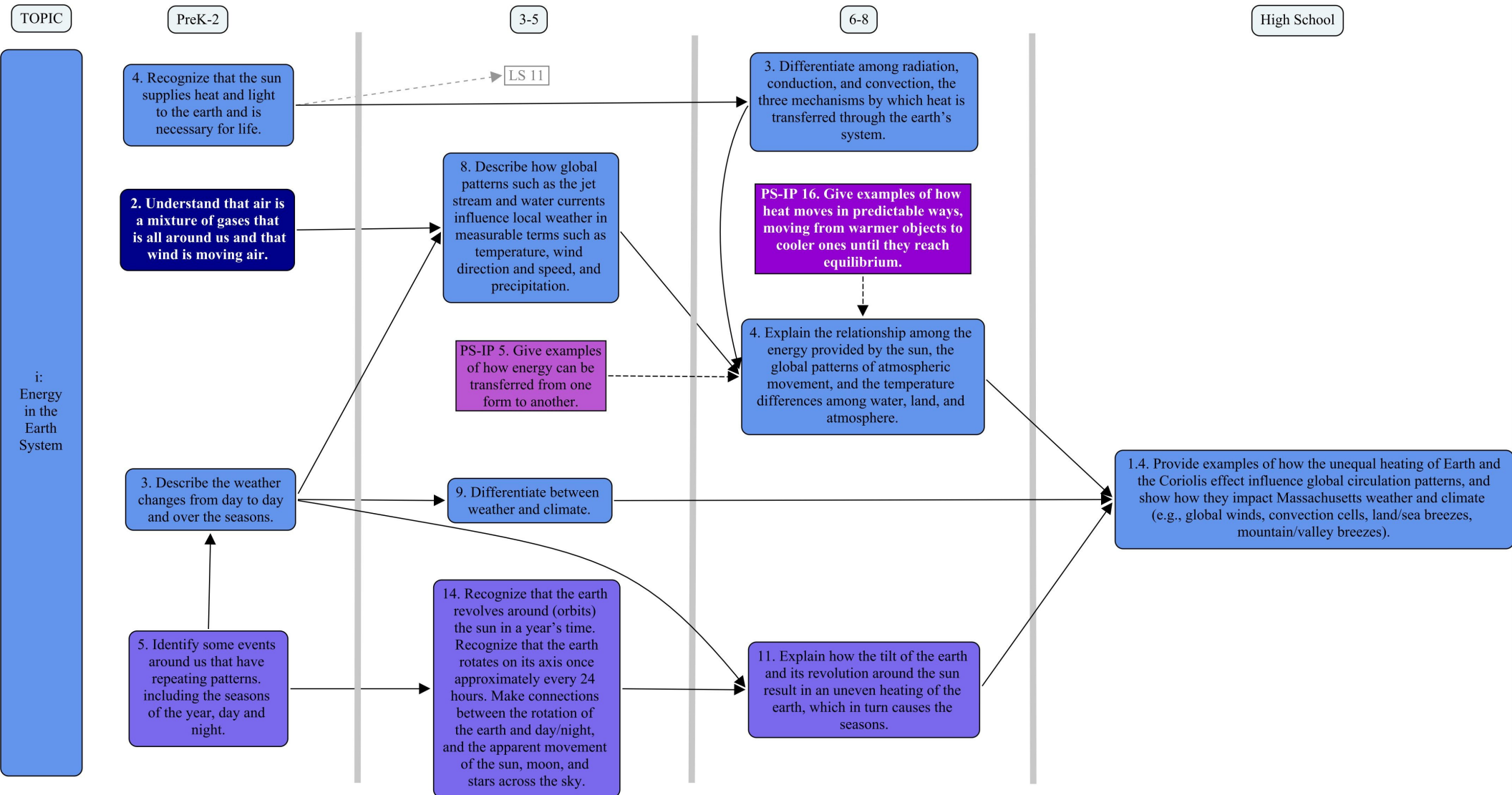
4.2a. Explain how the circulatory system (heart, arteries, veins, capillaries, red blood cells) transports nutrients and oxygen to cells and removes cell wastes.

4.5a. Explain how the muscular/skeletal system (skeletal, smooth and cardiac muscles, bones, cartilage, ligaments, tendons) works with other systems to support the body and allow for movement.

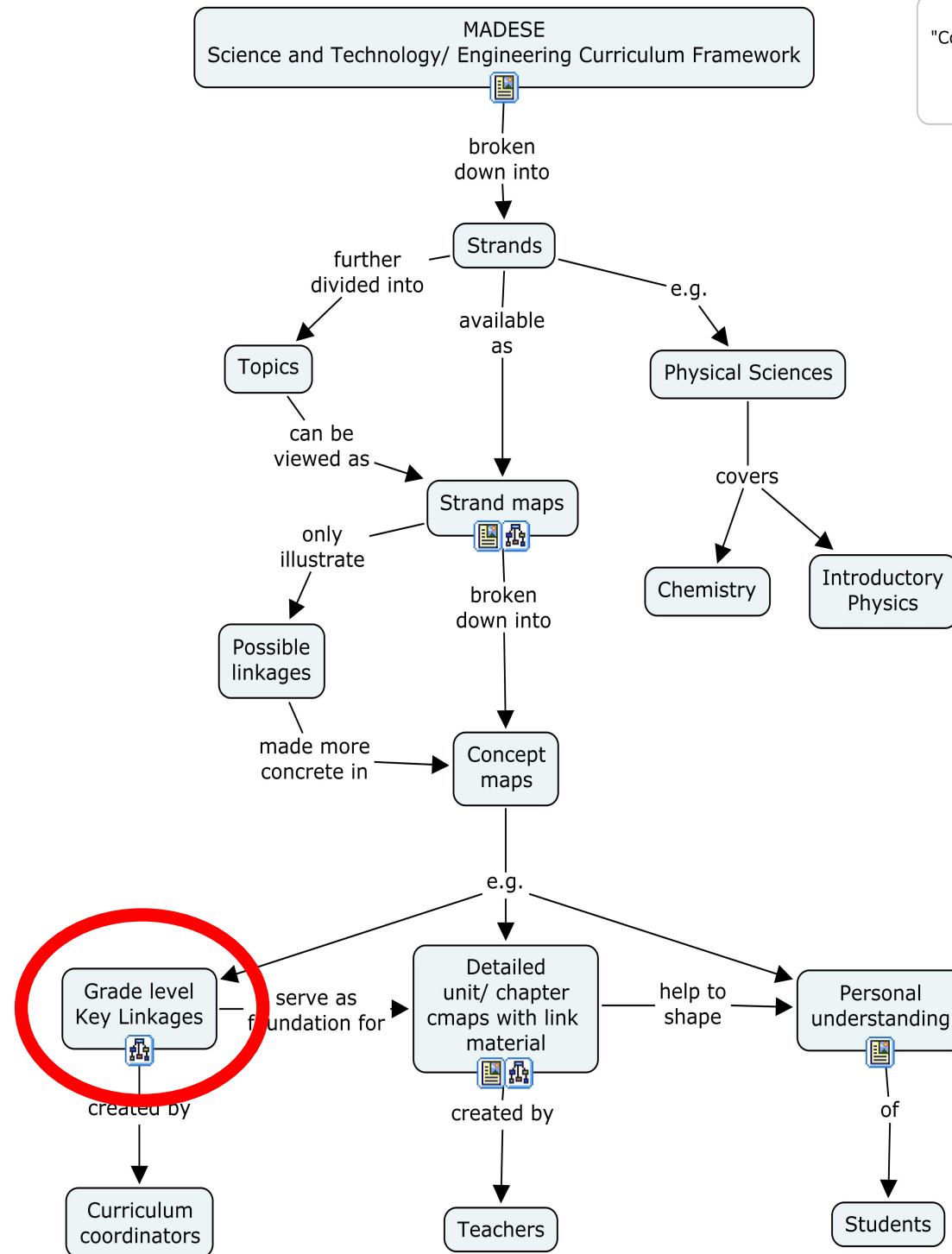
4.4a. Explain how the nervous system (brain, spinal cord, sensory neurons, motor neurons) mediates communication among different parts of the body and mediates the body's interactions with the environment.

4.6a. Recognize that the sexual reproductive system allows organisms to produce offspring that receive half of their genetic information from their mother and half from their father.

# Converging & Crosslinking Standards



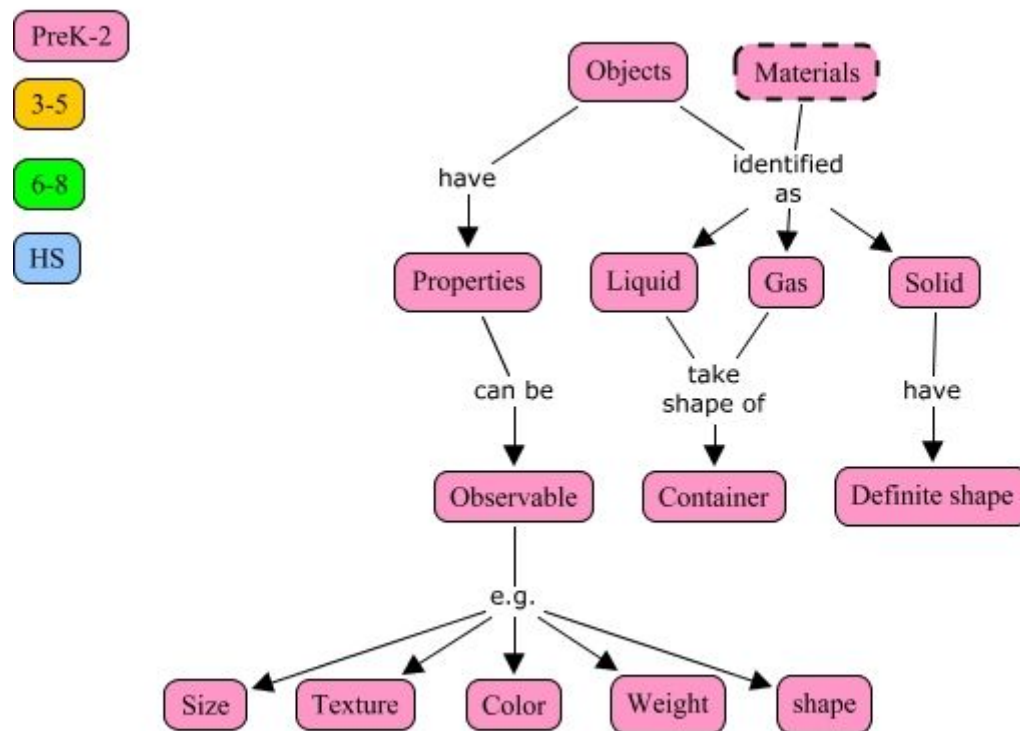
**Focus Question:** How could national/ state frameworks guide curriculum development and instructional practices?



This is a demonstration of the educational vision laid out in "Conceptual Mapping to Facilitate Review of State Science Standards" and not a full implementation  
by James Gorman  
**jgorman@nps.org**

<http://cmapspublic3.ihmc.us/rid=1H>

# Chemistry: Properties of Matter

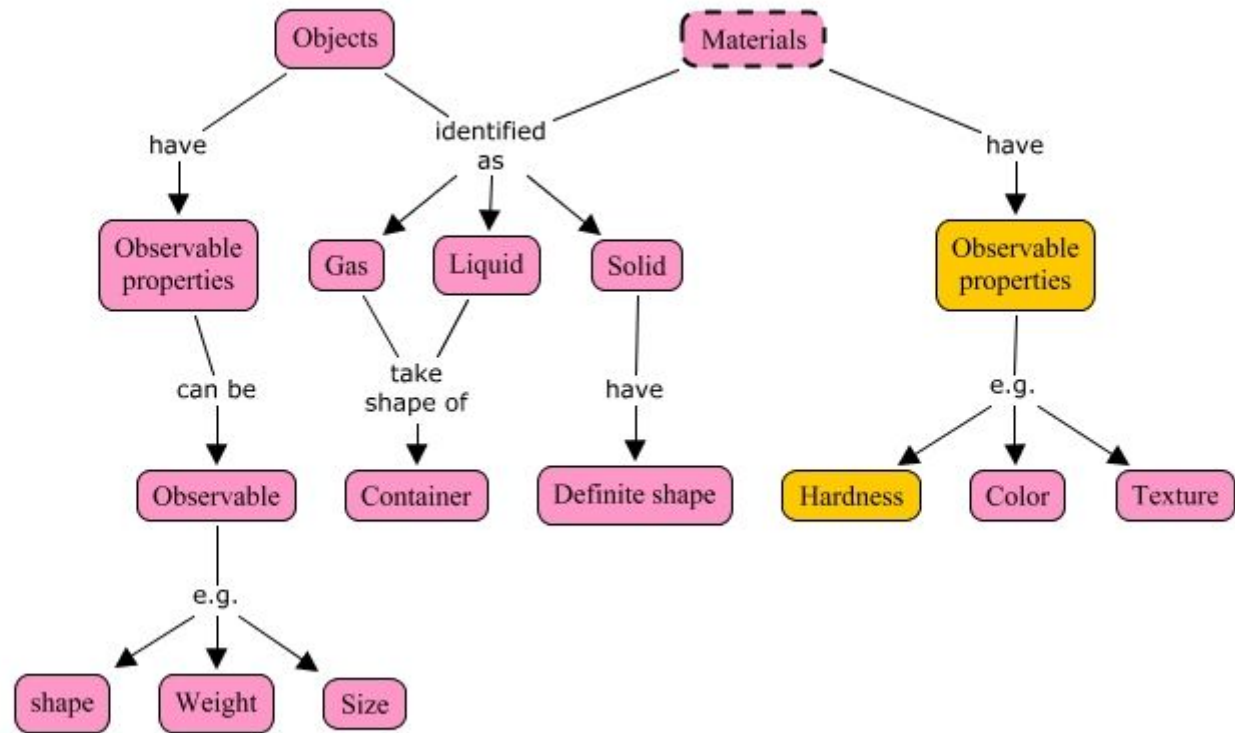


PreK-2

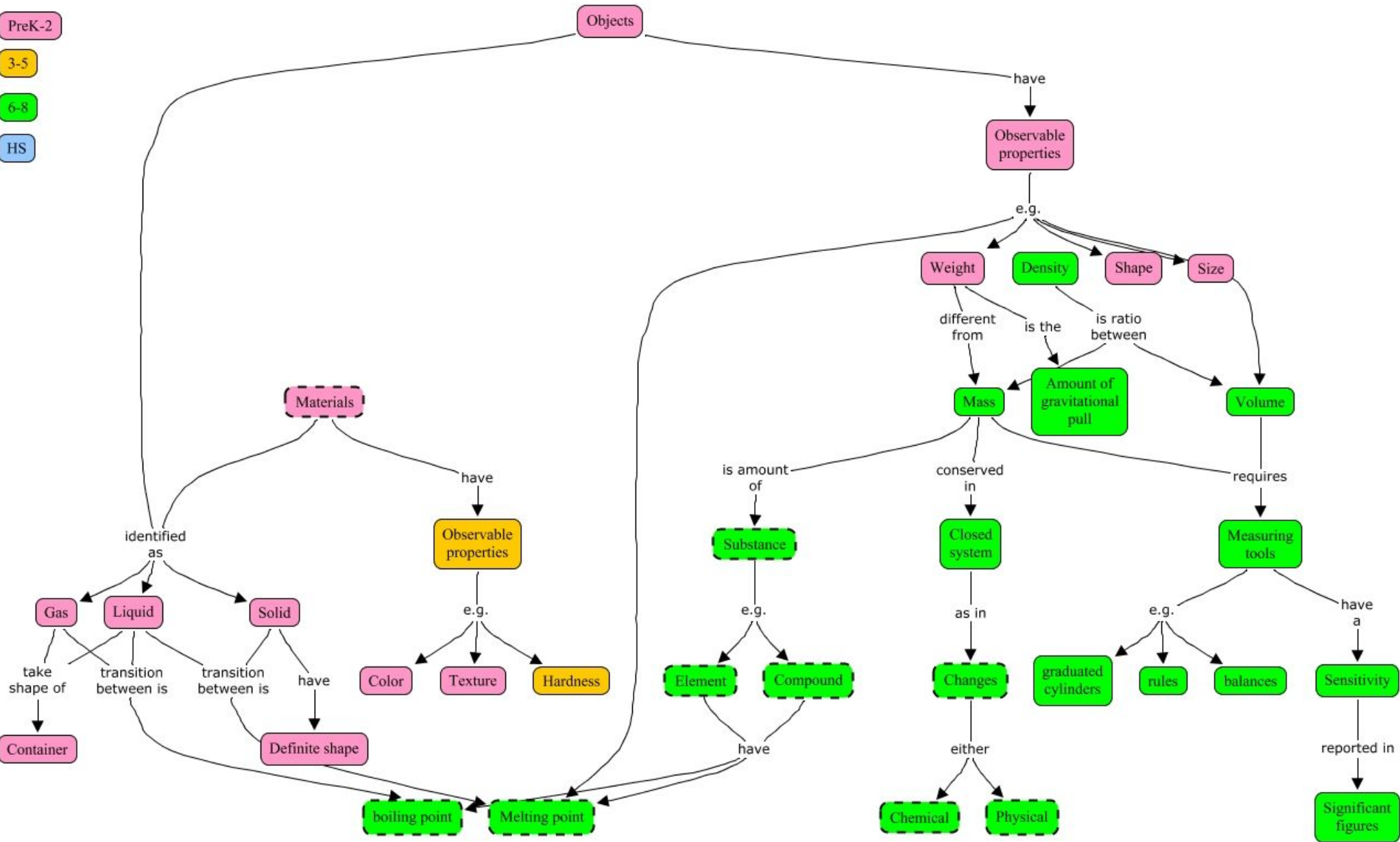
3-5

6-8

HS







MADESE 2006 Physical Science (Chemistry) Frameworks  
Conceptual Development Over Time

Draft

Legend

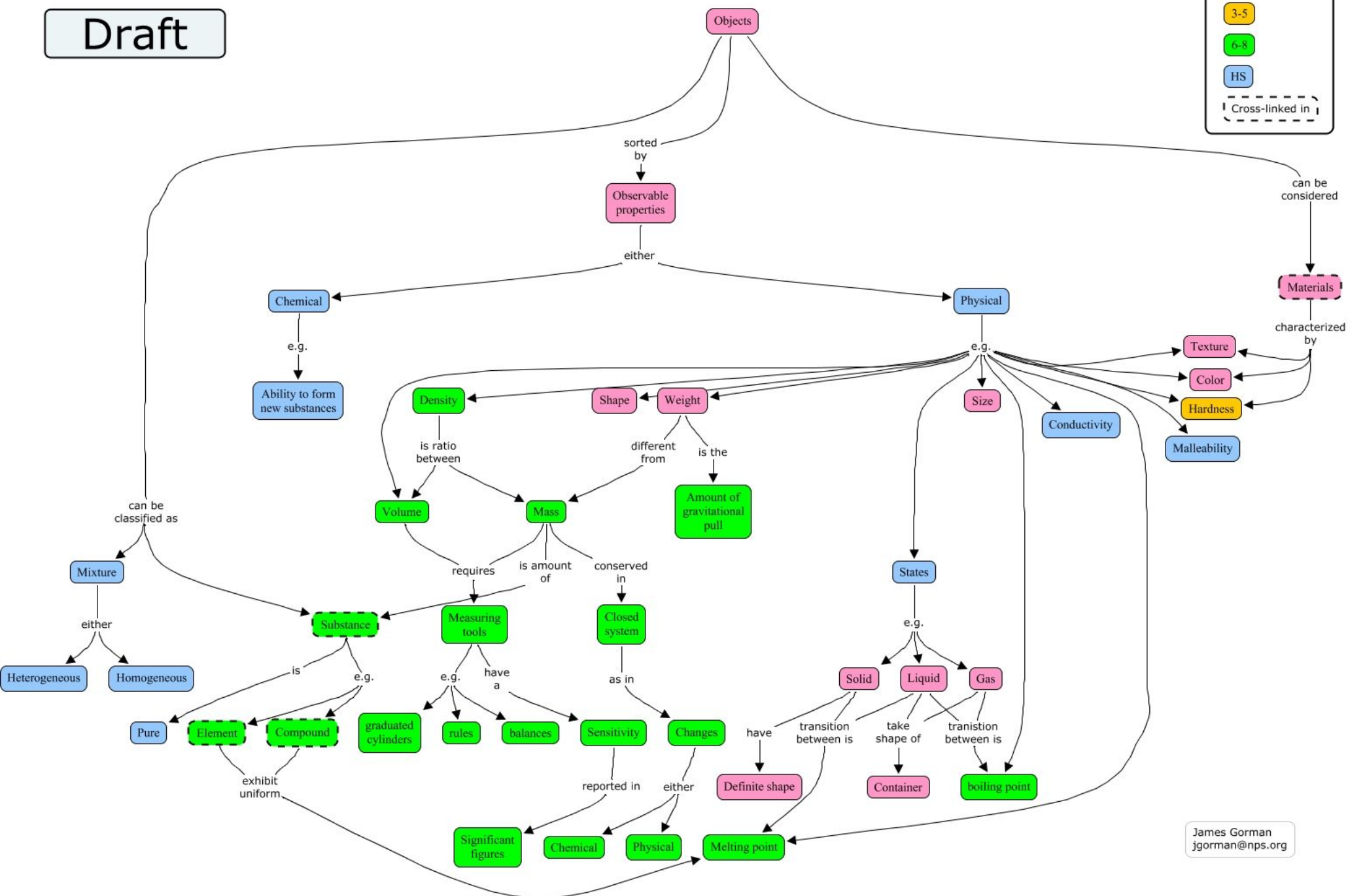
PreK-2

3-5

6-8

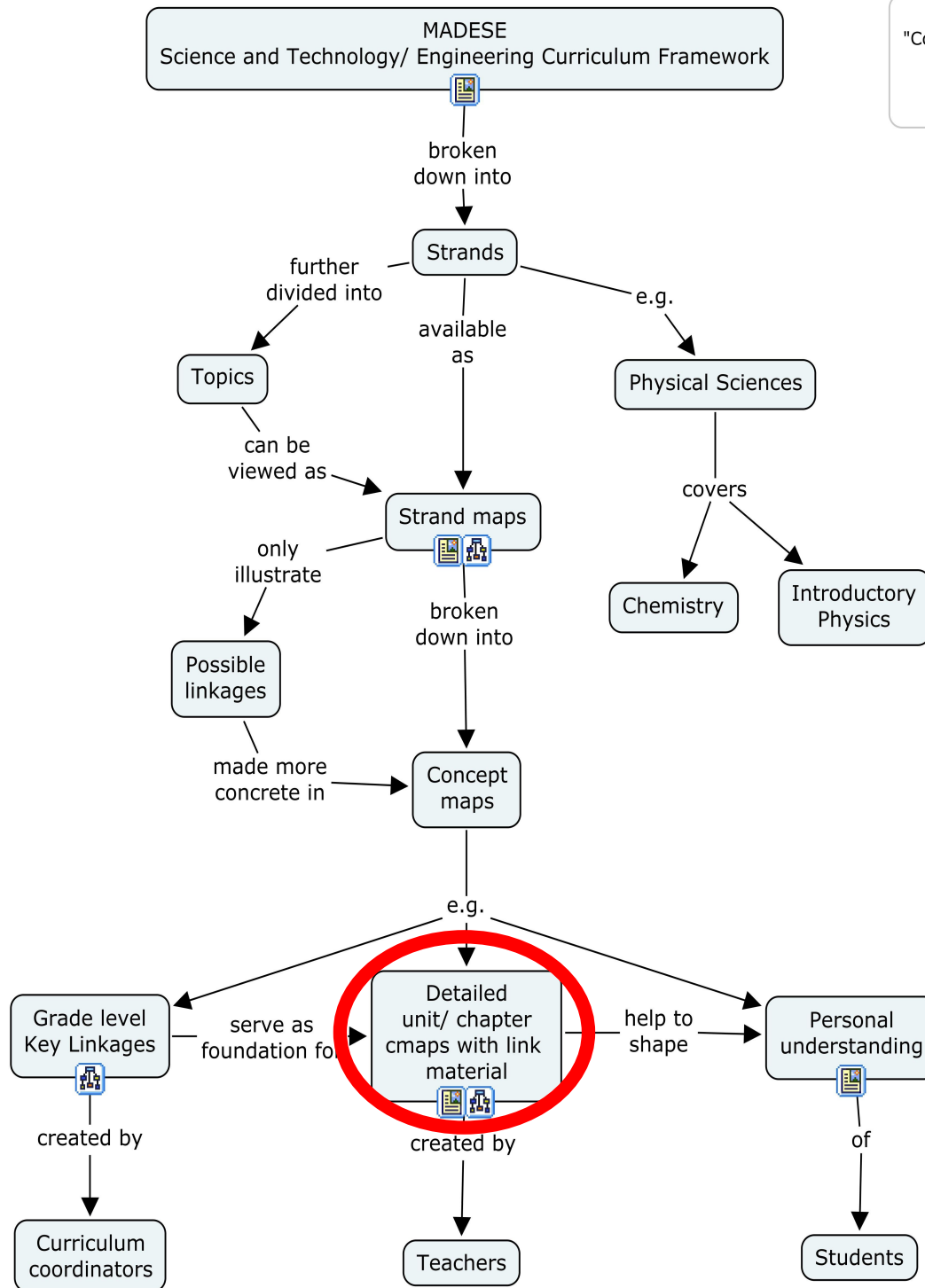
HS

Cross-linked in





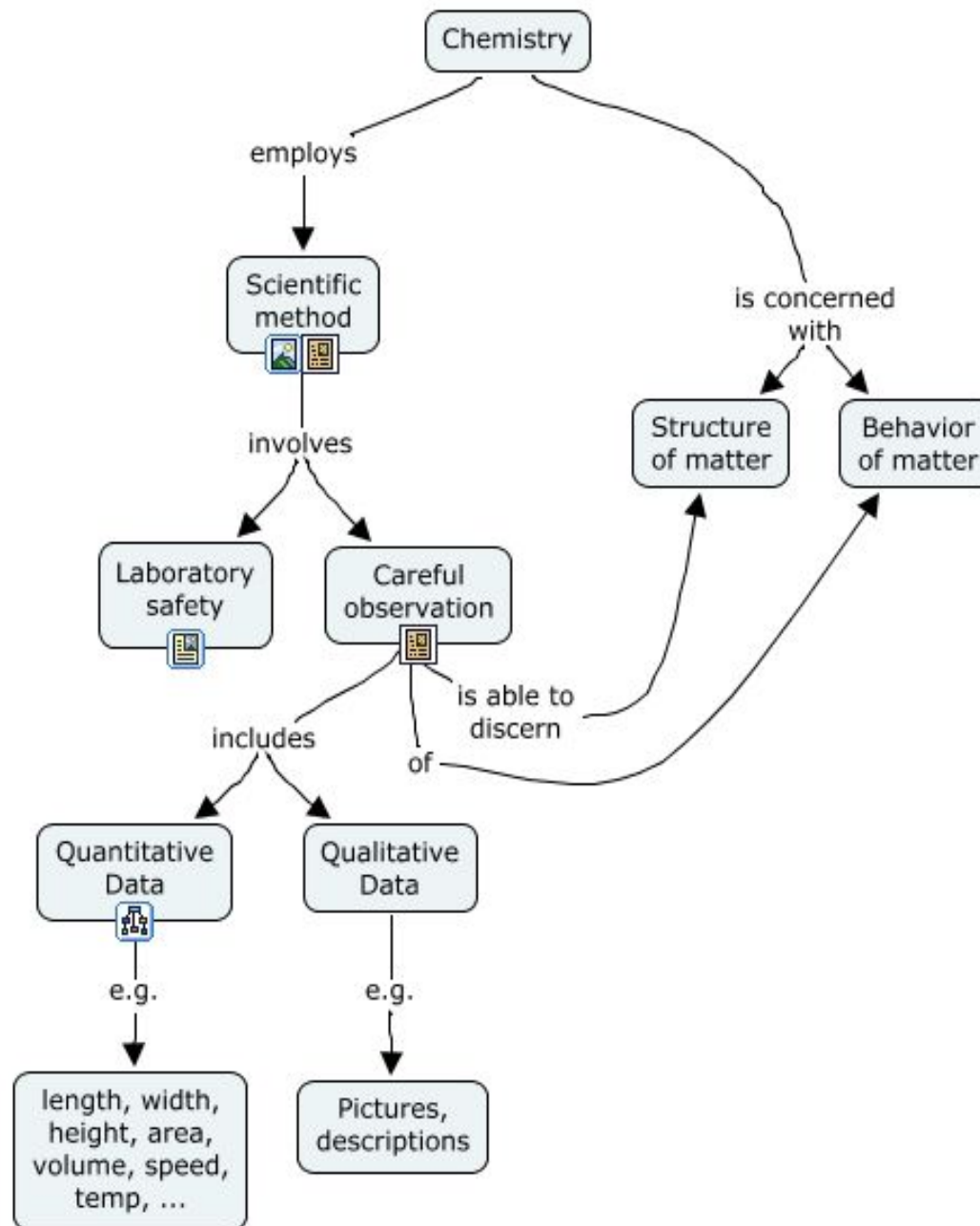
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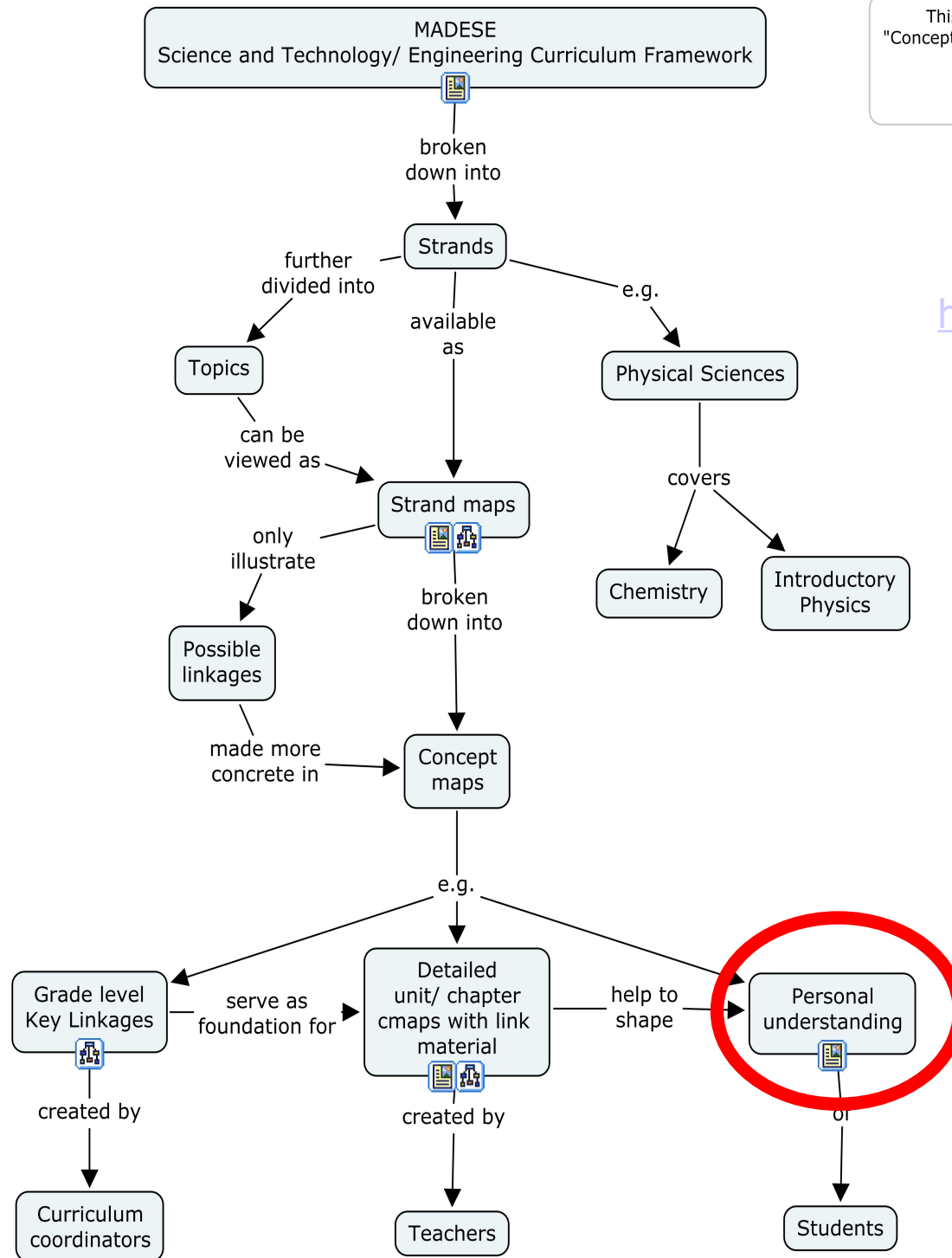
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<http://cmapspublic3.ihmc.us/rid=1H>

**Focus Question:** What is the essential nature of chemistry?



**Focus Question:** How could national/ state frameworks guide curriculum development and instructional practices?



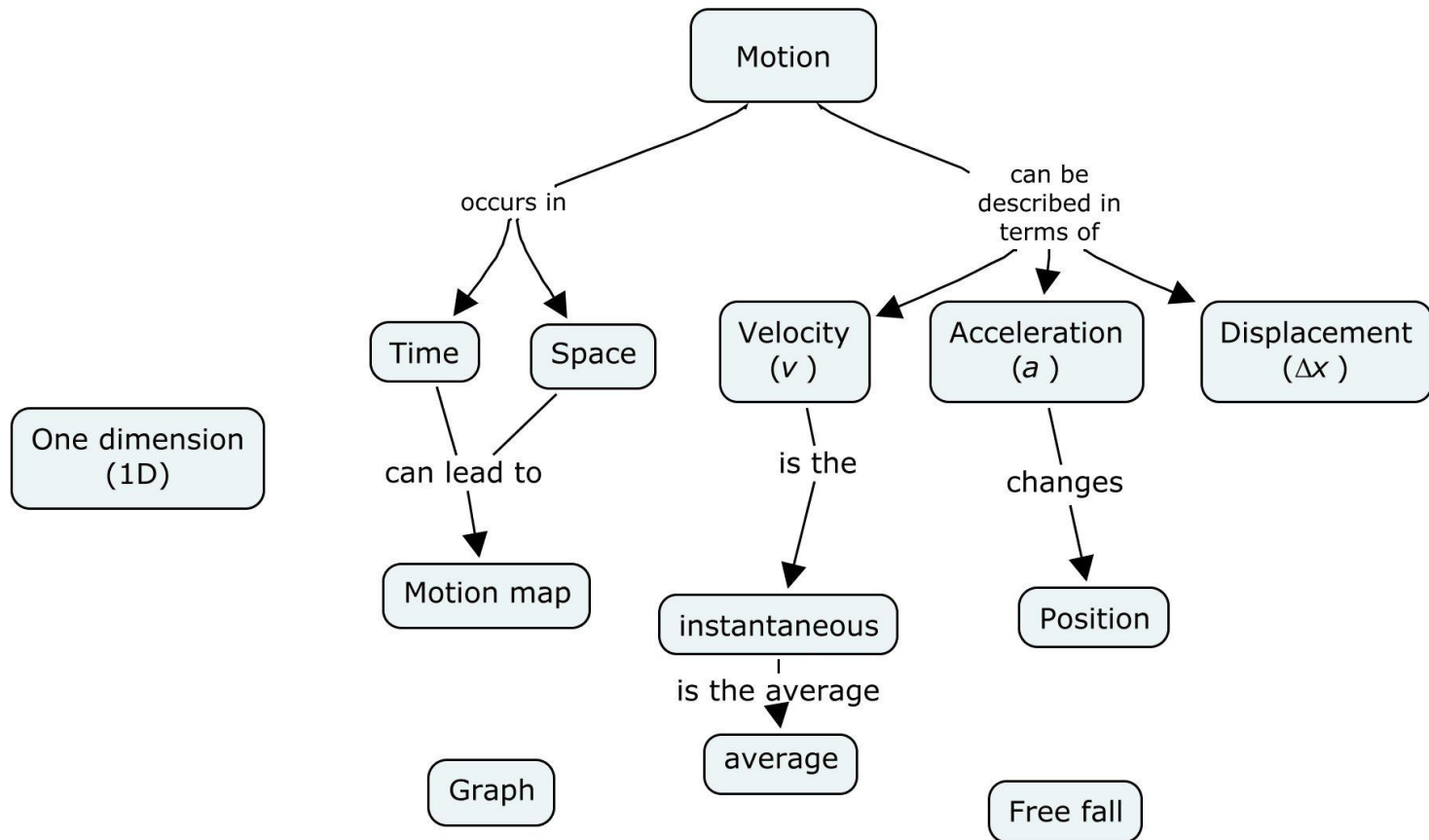
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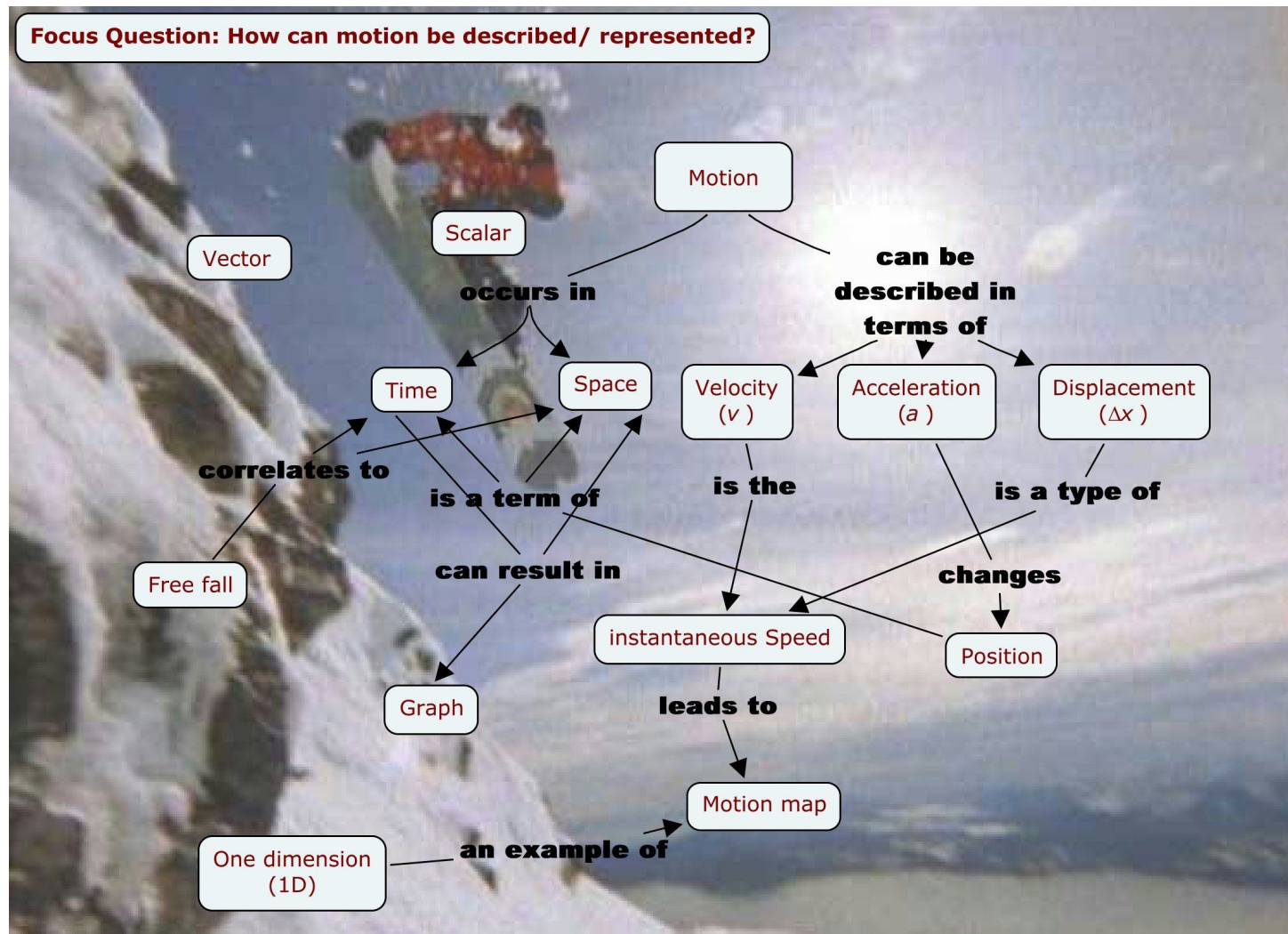
# Student Example over time

## 1D Motion Cmap

Focus Question: How can motion be described/ represented?

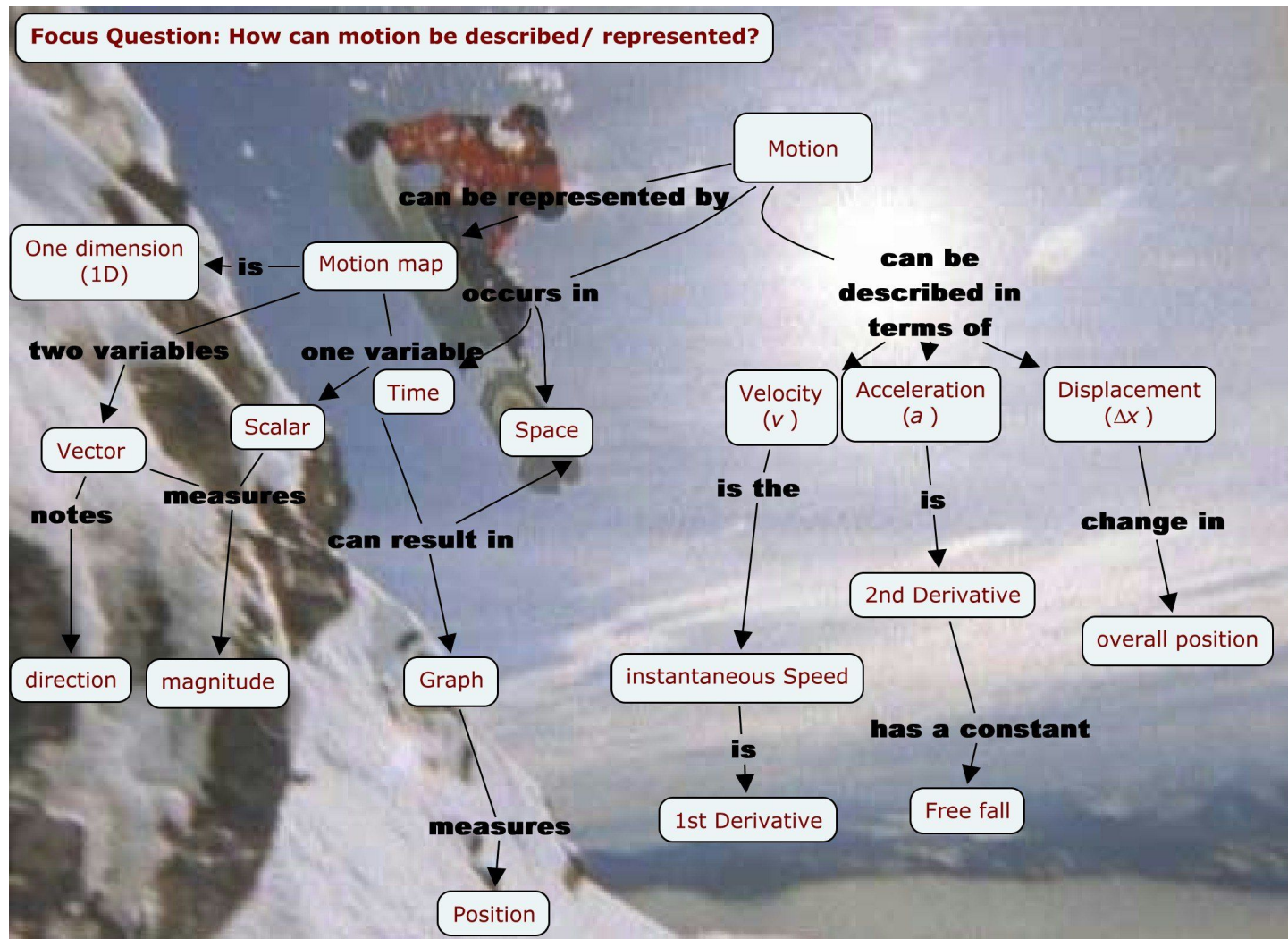


# 1D Motion Cmap 2

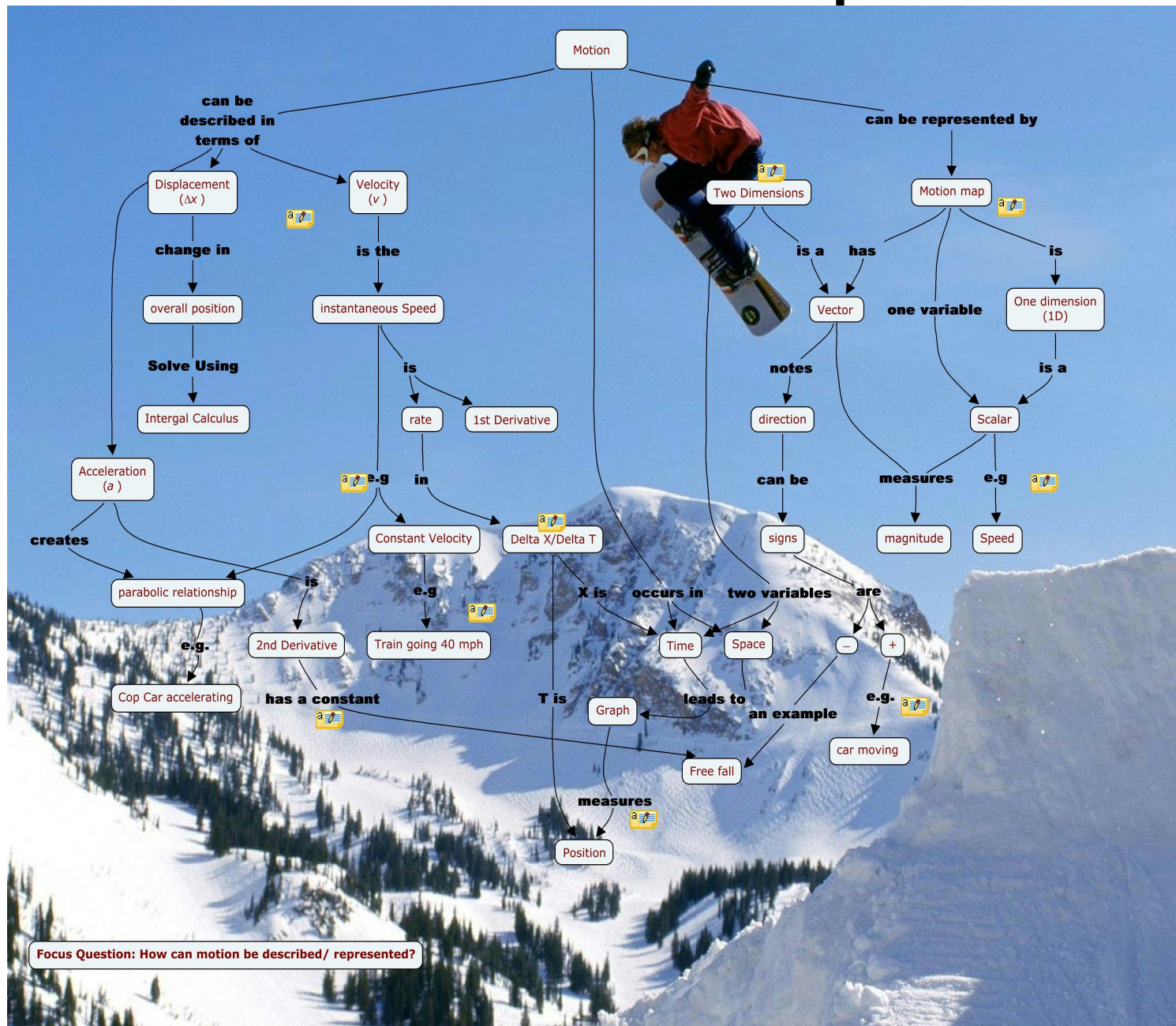




# 1D Motion Cmap 3

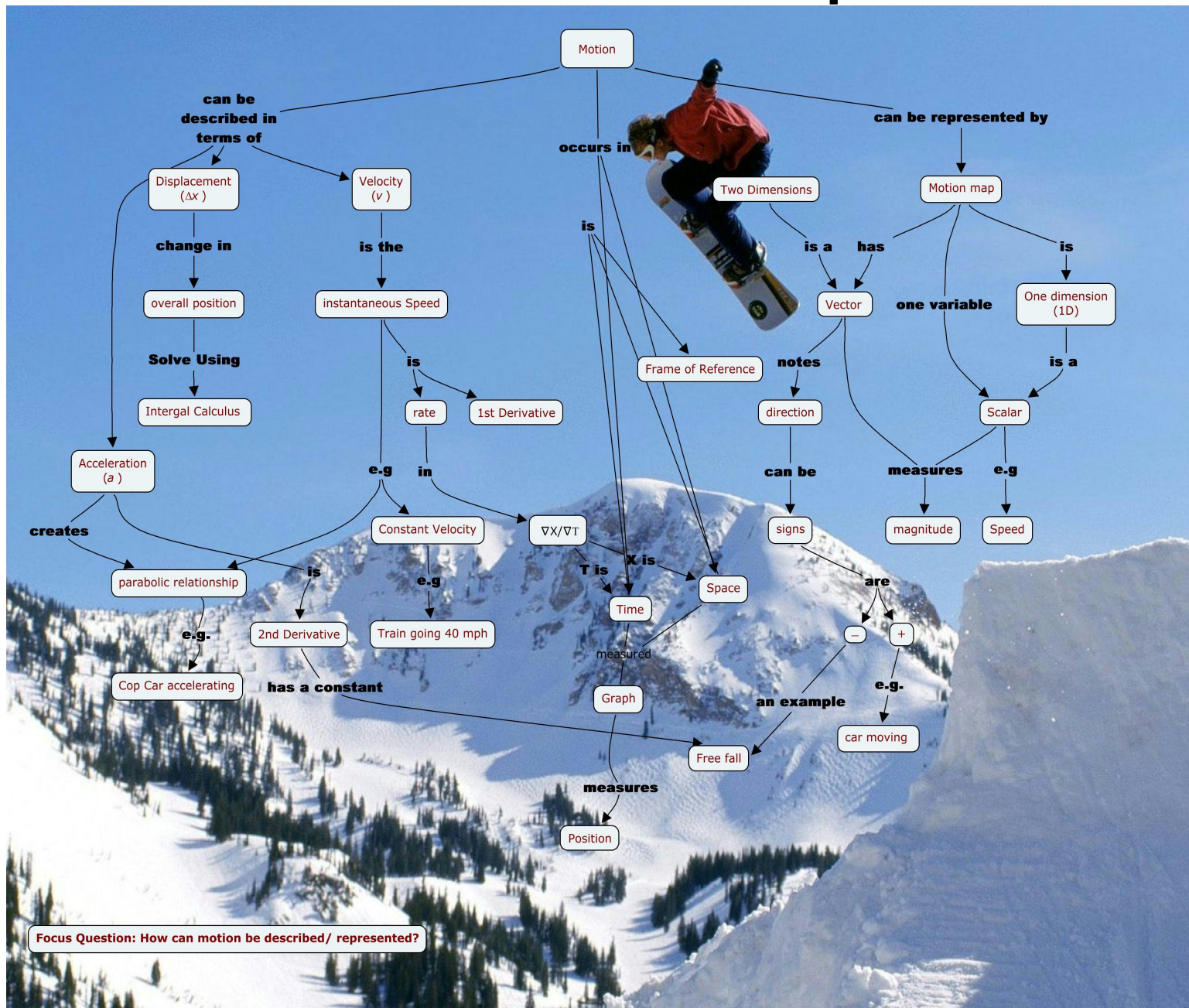


# 1D Motion Cmap 4





# 1D Motion Cmap 5



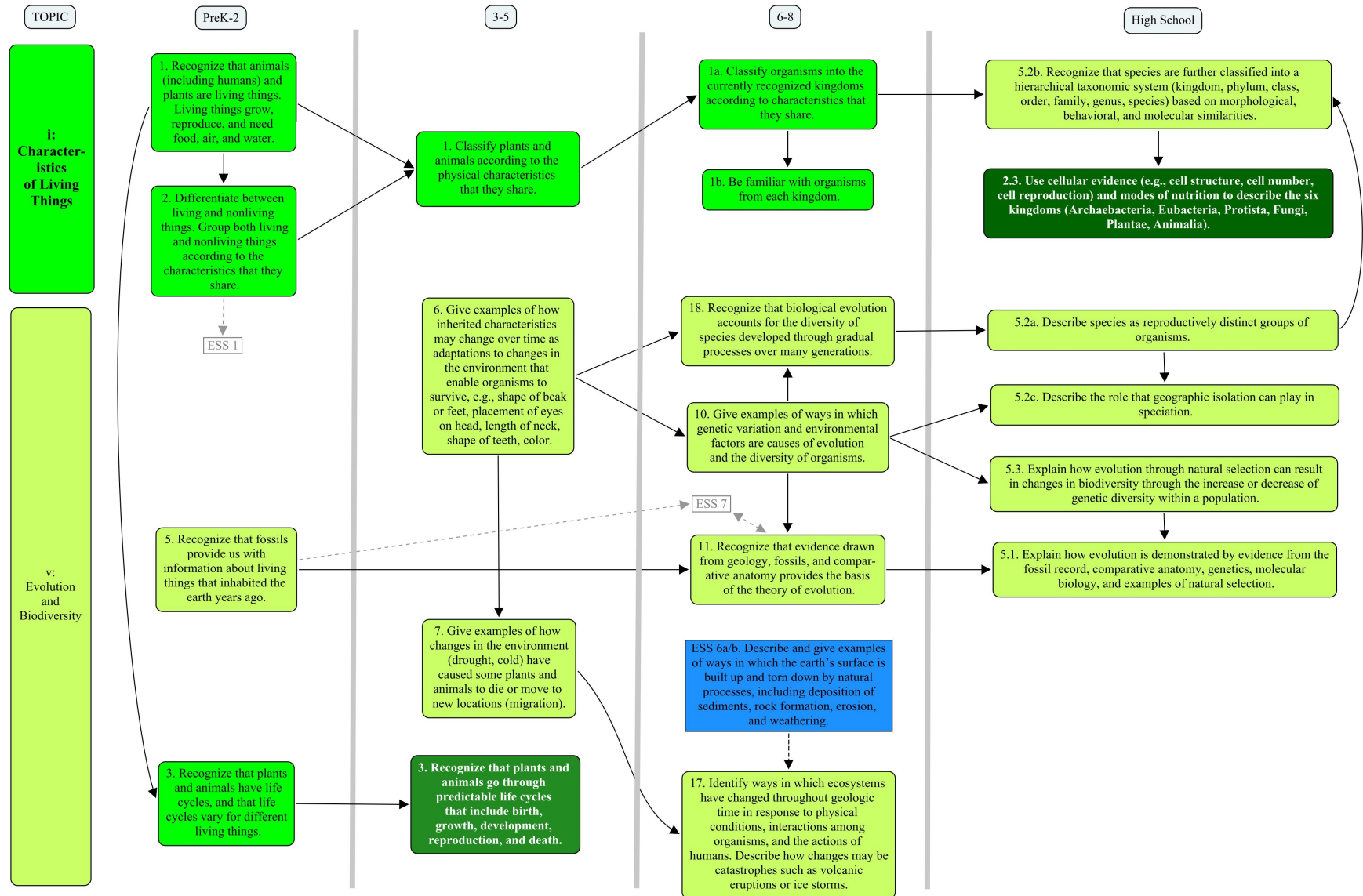


Thank you very much!

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# Figure 2



Standard = numbered phrase in the  
MA STE Framework  
(color coded to the topic it is currently  
associated with)

**5. Describe the hierarchical organization of multicellular organisms from cells to tissues to organs to systems to organisms.**

A standards specifies what students should know and be able to do:

- Demonstrated knowledge *and* skills
- Assessable and/or measurable

Concept = a conceptual unit of understanding  
(may be a whole or partial standard)

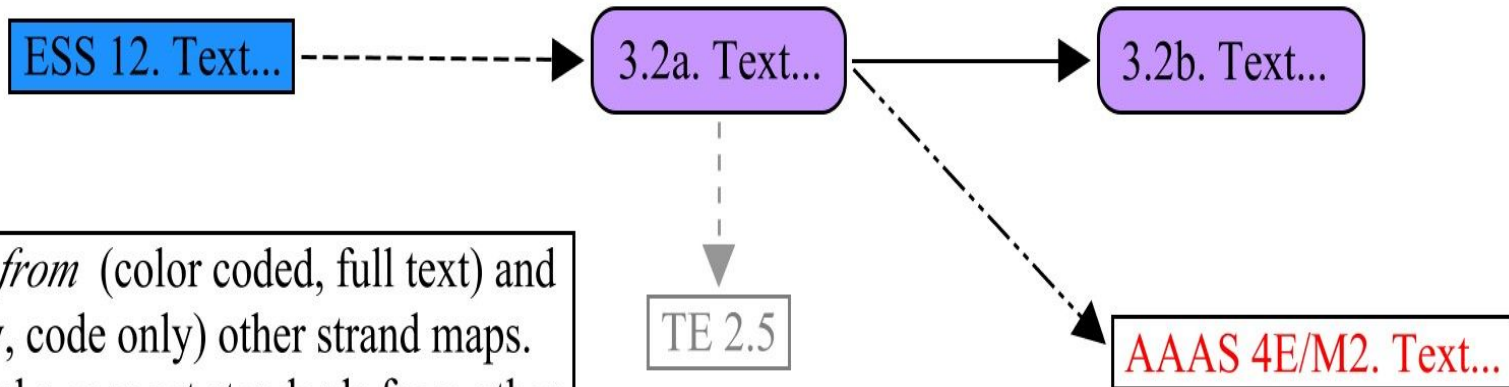
Some standards were split if they included multiple concepts or skills that stand on their own (but not always).

9a. Recognize plant behaviors, such as the way seedlings' stems grow toward light and their roots grow downward in response to gravity. (!?)

9b. Recognize that many plants and animals can survive harsh environments because of seasonal behaviors, e.g., in winter, some trees shed leaves, some animals hibernate, and other animals migrate. (!?)

# Key to Strand Map

Original standards, color coded by topic.  
Solid link connects standards within the strand map.



Standards *from* (color coded, full text) and *to* (gray, code only) other strand maps.  
Dashed links connect standards from other strand maps.

Additional AAAS benchmark (not in standards).  
Variable dashed link connects AAAS benchmarks.

Notation at the end of a standard indicate particular comments found on the corresponding notes pages. Ex: (?!)(2)

# Assumptions Underlying the Strand Maps

**Some assumptions were made in the creation of the maps that will assist in interpreting the meaning of the maps.**

# Assumption 1

*Links show how standards contribute to one another*

- Linking arrows = connections that are *necessary* for learning, NOT *possible* connections between concepts (In AAAS Atlas language: “one contributes to achieving the other”).
- An arrow *leaving* a standard implies that the concept contributes to learning the concept of the next/connected standard.
- These links are primarily based upon:
  - Wisdom of practice, professional judgment
  - Logic of the subject matter
  - Cognitive research specific to a particular idea
  - General principles of cognitive development: for ex: concrete

# Assumption 2

*The strand maps represent the current STE Framework*

- Standards are always kept within the grade span and strand in which they currently are found in the Framework.
- The topic the standard is associated with may shift within the strand.
- Coloring designates the original topic (where the standard currently resides in the Framework).



# Assumption 3

*Simple is better*

- Tried to have as few arrows as was necessary.
- The placement of standards (or concepts) is first by affiliation to a topic, and then placed to reduce any “spaghetti” effects.