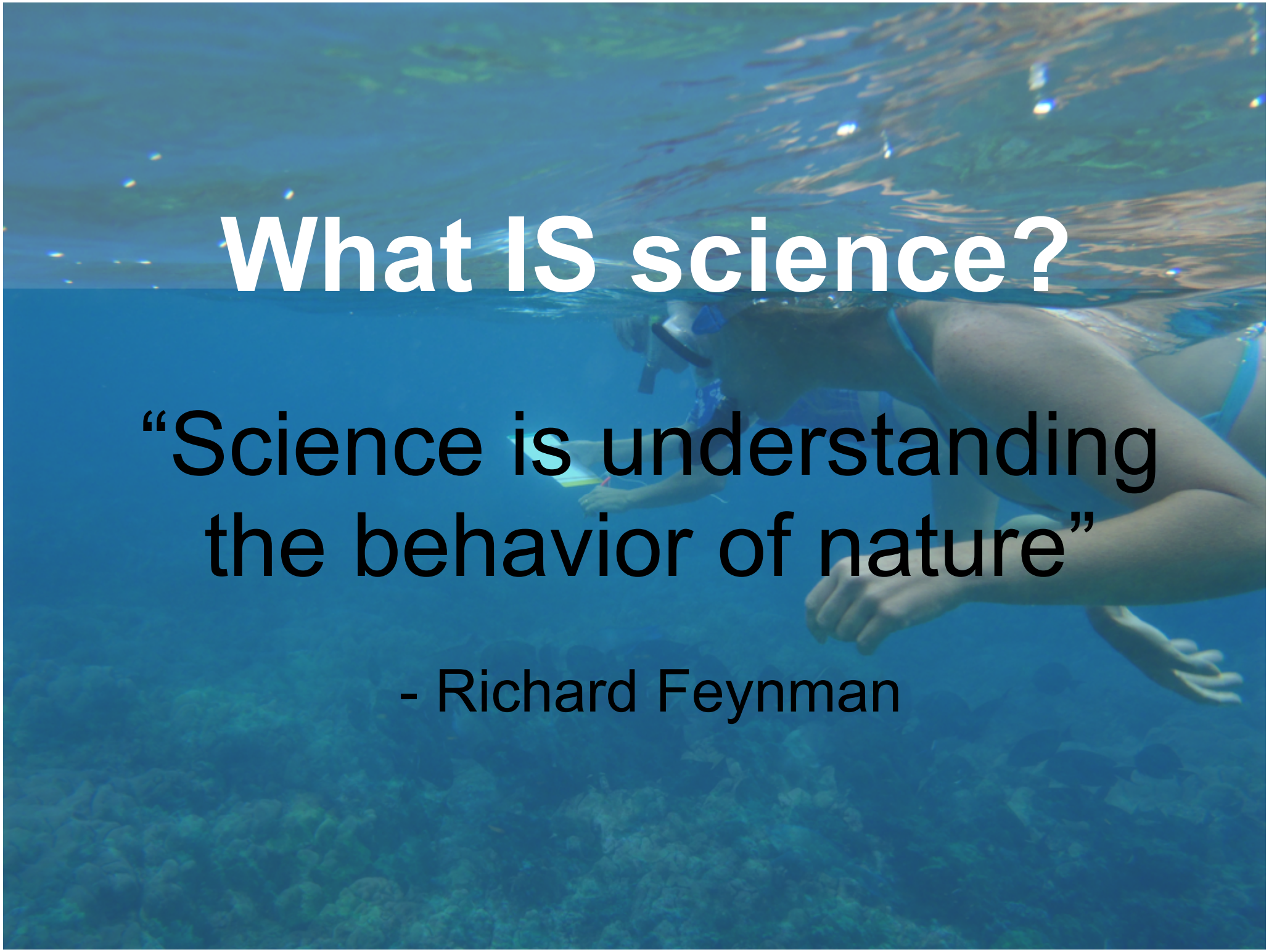
Practices of Scientists
Part A-C
(Part D & Extension later today)

Practices of Scientists

Activity Goals

- Identify and apply the practices of scientists
- Identify the attributes of the discipline of science
- Compare and contrast scientific practices with practices in other disciplines
- Connect with the practitioners of science ists) so that students begin to identify with scientists and view them as real people

What IS science?



What IS science?

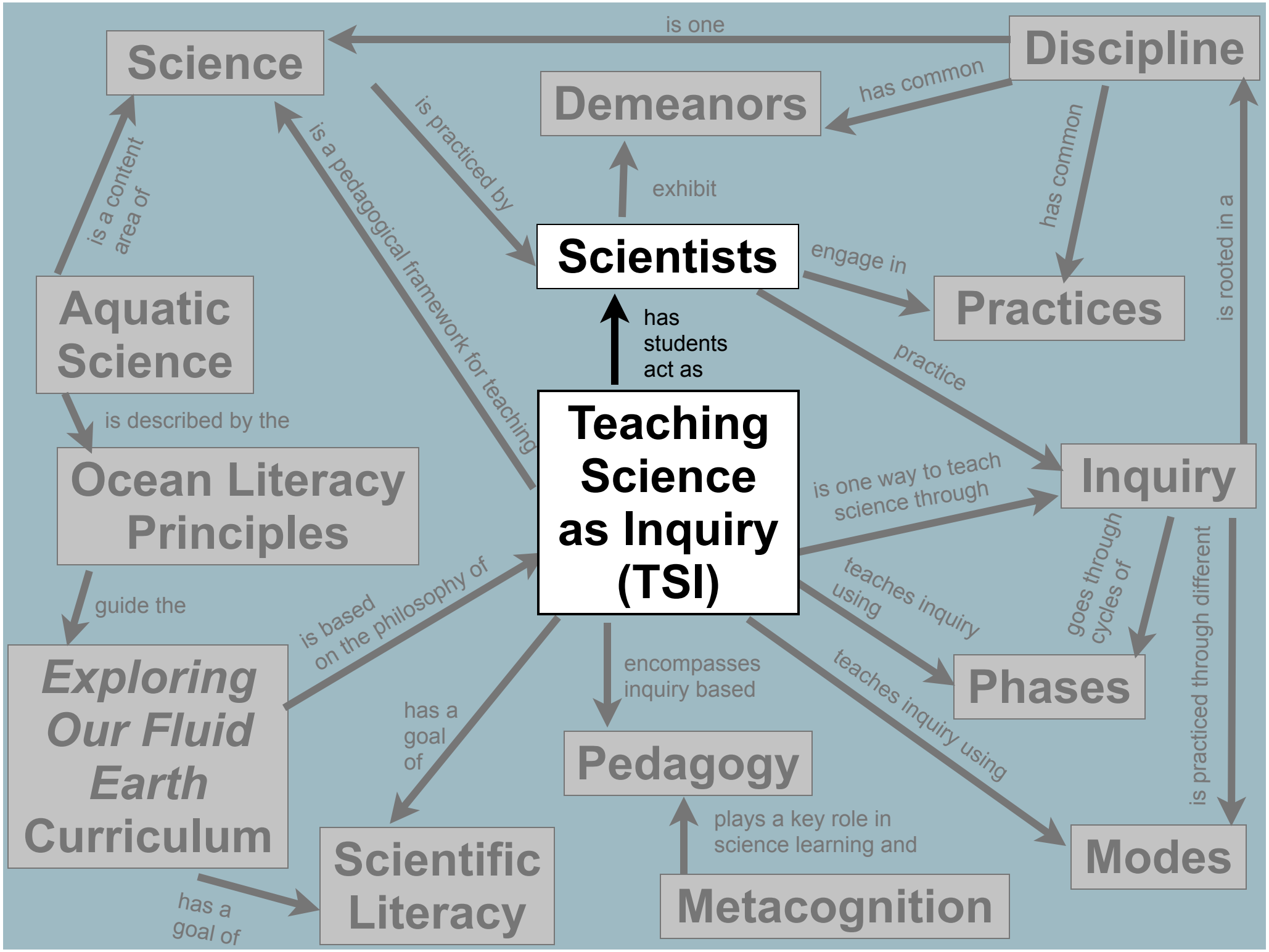
"Science is understanding the behavior of nature"

- Richard Feynman

What IS science?

"Science involves more than the gaining of knowledge. It is the systematic and organized inquiry into the natural world and its phenomena. Science is about gaining a deeper and often useful understanding of the world."

- from the Multicultural History of Science page at Vanderbilt University.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Scientific Literacy
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Modes

What IS a scientist?

82% of Americans surveyed in 2004 by NSF said they do not know any scientists

Draw A Scientist

Draw what you think a scientist looks like

Describe Scientist Drawings

- Trade your drawing with a partner.
- Write down at least 5 words to describe *your partner's* scientist drawing
- We will then make a class list

Class Descriptions

- Which word categories are the most common?

- What do the word categories tell you about the drawings?

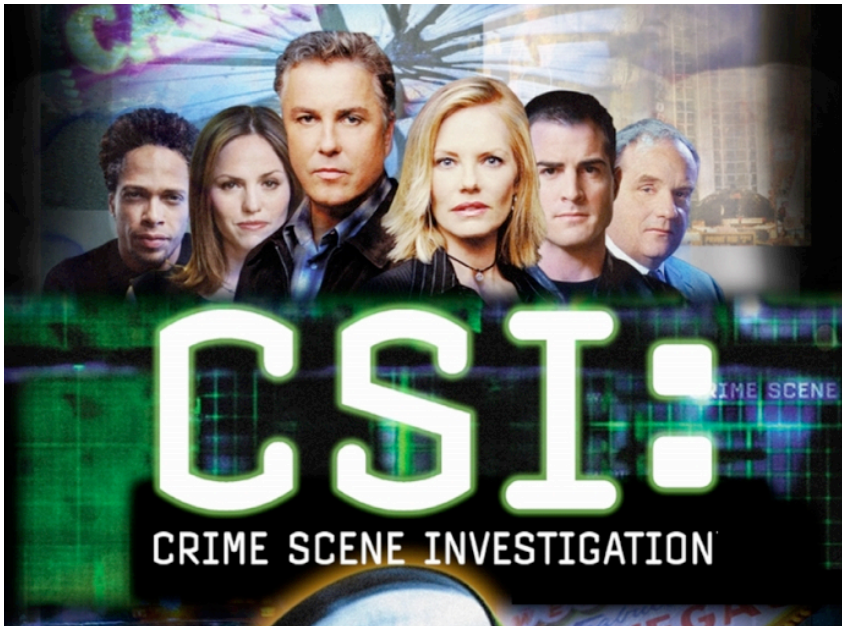
Draw a Scientist

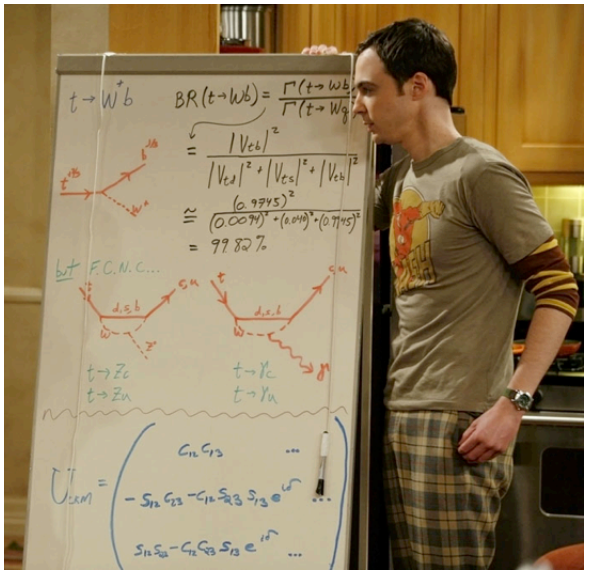
- Mead and Metraux (1958)
  - lab-coat-wearing,
  - old men of either tall-and-thin or small stature
  - work in a laboratory
  - surrounded by glassware
  - facial hair (indicating mature male)
- Chambers' (1983) - 4,807 students
- Thomas and Hairston's (2003) 757 students
  - lab coat
  - eyeglasses
  - facial hair (indicating mature male)

What IS a scientist?

Does media portrayal help?

- Popularity of Crime Scene Investigation (CSI) type TV shows may glamorize and alienate science practices more than making science accessible





- CSI juror effect

(Willing 2005, Deutsch 2006)

Defining Science

In your group, come up with at least three words words or phrases to describe:

- The **discipline** of science (the attributes that make up the field, or practice, of science)
- The **demeanors**, or characteristics, of scientists (that scientists value)

For the purposes of this activity
***Idealized* scientists**

Defining Science

In your group, come up with at least three words words or phrases to describe:

- The **discipline** of science (the attributes that make up the field, or practice, of science)
- The **demeanors**, or characteristics, of scientists (that scientists value)

Defining Science

- What does it mean to practice science?

Discipline

- A community of persons
- An expression of human imagination and ingenuity
- A mode of inquiring about the word
- A tradition
- A conceptual structure
- A specialized language or other system of symbols
- A heritage of literature and artifacts and networks of communication
- A system of values and demeanors
- An instructive community

Defining Science

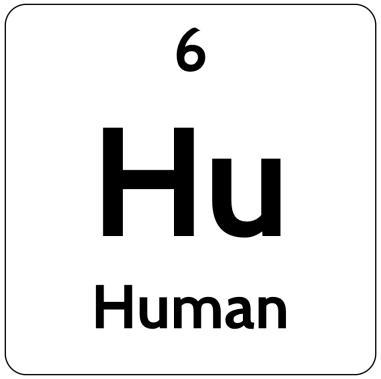
- What are the characteristics of scientists?

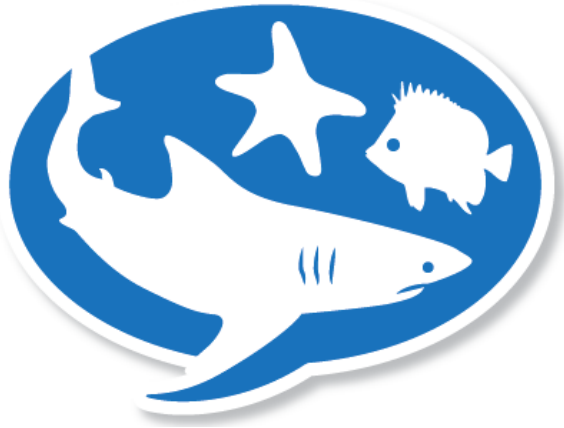
Demeanors

- Responsibility
- Courtesy
- Skepticism
- Respect for ideas of others
- Accuracy
- Honesty
- Open mindedness
- Evidence-based evaluation

Disciplinary Inquiry

- Teaching via inquiry through the **authentic practice of science**
    - Science is a community process
    - Replicate scientific community in the classroom





Disciplines

Math

Public Policy

Marketing

Journalism

Finance

Sociology

Visual Arts

Music

Economics

One discipline is not better than another, they are just different ways of looking at the world

Political Science

Science

Philosophy

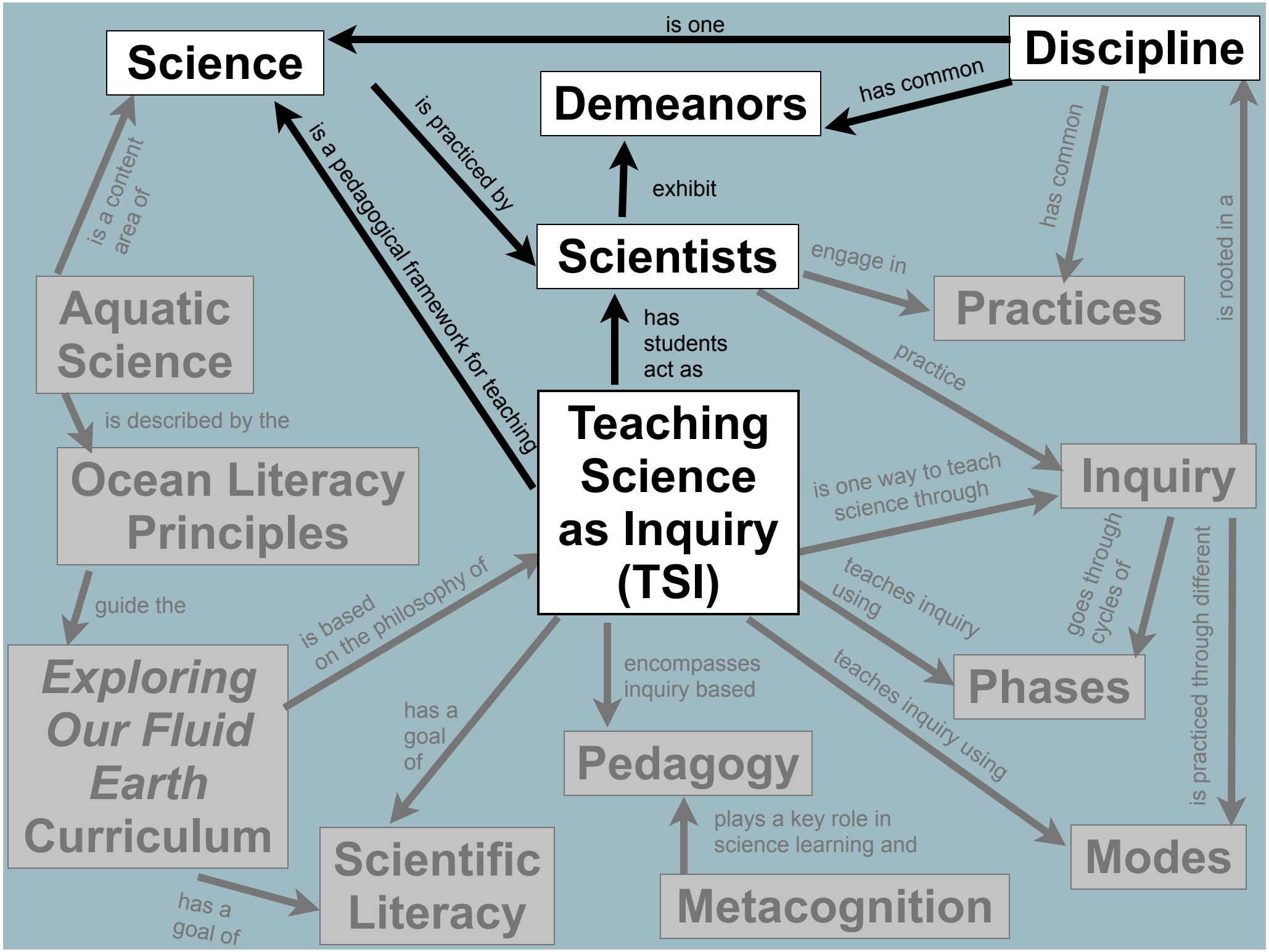
Social Work

Interior Design

Architecture

Computer Science

Religion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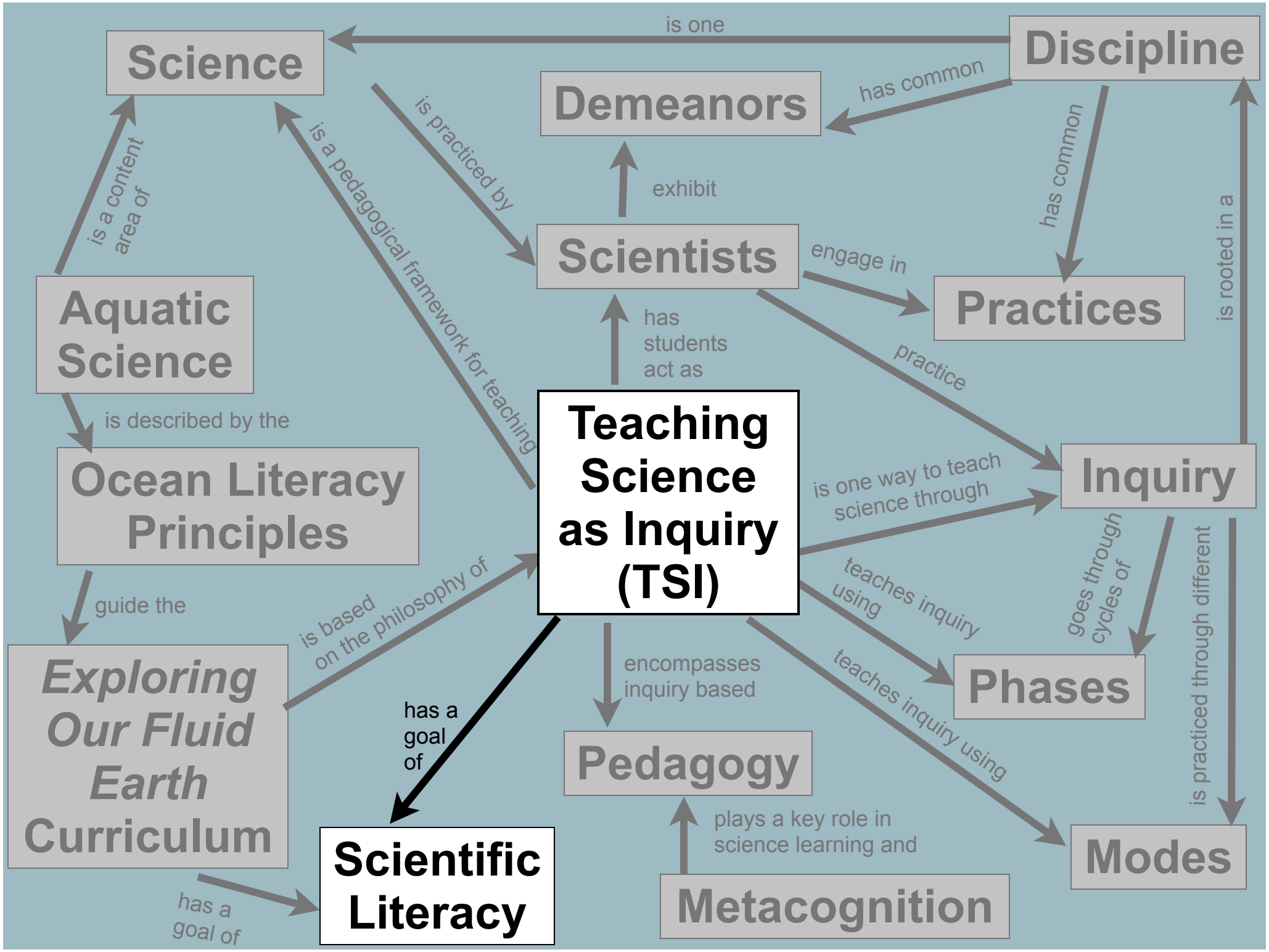
Practices of Scientists

Extension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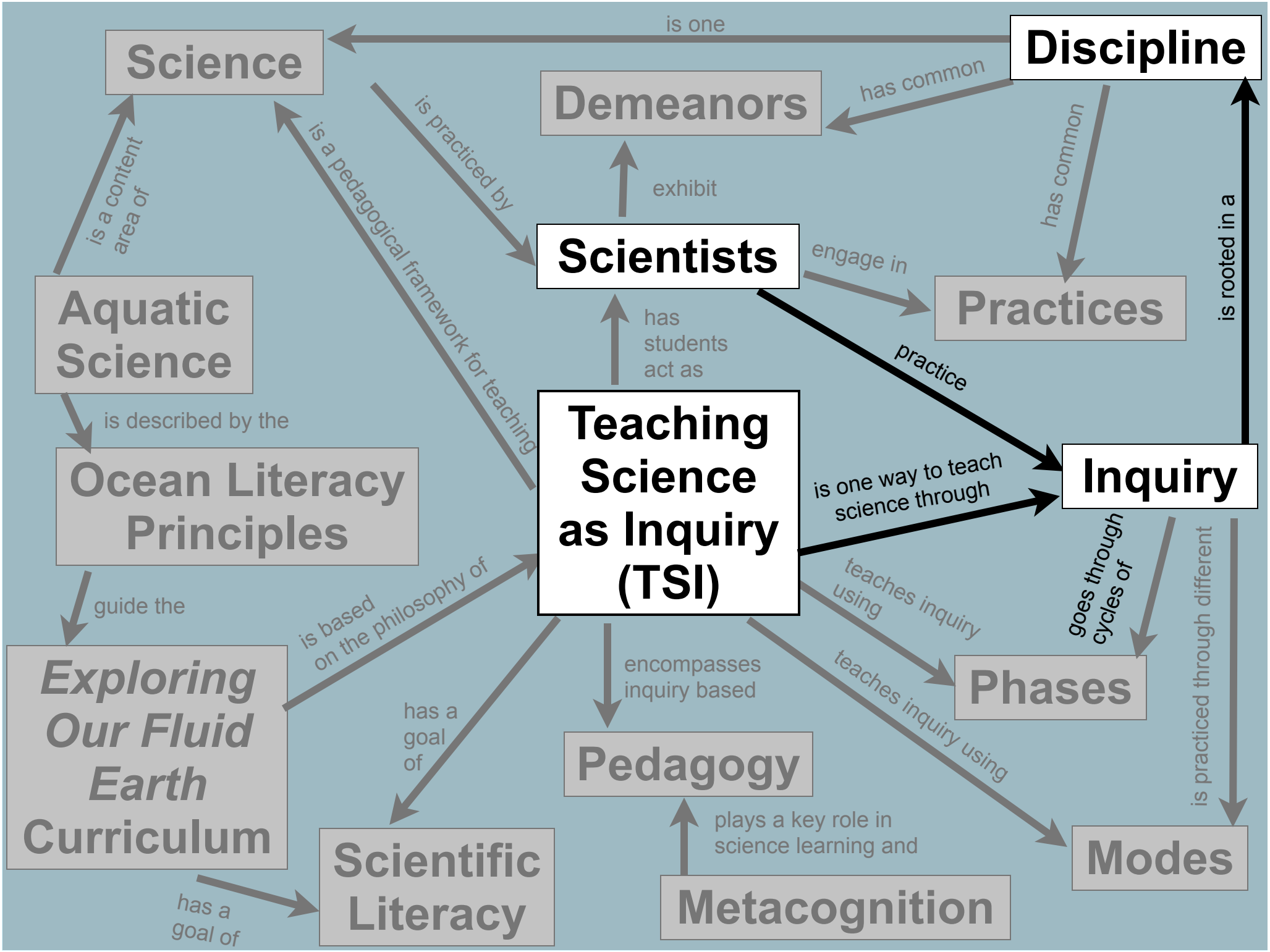
Scientific Literacy

Those who are scientifically literate “have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology”.

National Research Council 2011

Literacy Categories

- Visual
- Numerical
- Multimedia
- Information
- Computer
- Technological
- Ocean
- Climate
- Geographical
- Sexual
- Health
- Critical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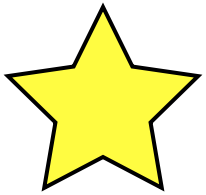
Working Definition of Inquiry

National Research Council (1996)

- **INQUIRY.** Scientific inquiry refers to the **diverse** ways in which **scientists** study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of **students** in which they develop knowledge and understanding of scientific **ideas**, as well as an understanding of **how** scientists study the natural world.

Soda and Scientific Reasoning



Soda & Scientific Reasoning

In regular tap water, what will happen to each of the following cans?

Yes

No

Metacognition

- Thinking about your thinking
- Awareness of your thinking processes

Soda & Scientific Reasoning

Use your powers of observation, investigation, and scientific thinking to figure out why one can floated and the other sank.

Soda & Scientific Reasoning

Activity Goals

- Use the practices of science in an investigation of density and buoyancy.

Soda & Scientific Reasoning

Procedure 2:

- What soda can variables affect sinking and floating?
- Fill in ‘Variable’, ‘Prediction’, and ‘Explanation’ in Table 1.1

Soda & Scientific Reasoning

Variable	Prediction	Explanation	Observation

Soda & Scientific Reasoning

Procedure 3:

Develop a hypothesis for the observed floating and sinking of the demonstration cans.

Soda & Scientific Reasoning

Procedure 5:

- Choose at least three variables and make predictions for all your test soda cans.
- Fill in ‘Soda’, ‘Variable 1, 2, 3’, and ‘Prediction’ column of Table 1.2

Soda & Scientific Reasoning

Soda	Variable 1	Variable 2	Variable 3	Prediction: Sink or Float?	Observation: Sink or Float	Mass	Density

Soda & Scientific Reasoning

Use your powers of observation, investigation, and scientific thinking to figure out why one can floated and the other sank

Procedures 6 - 8

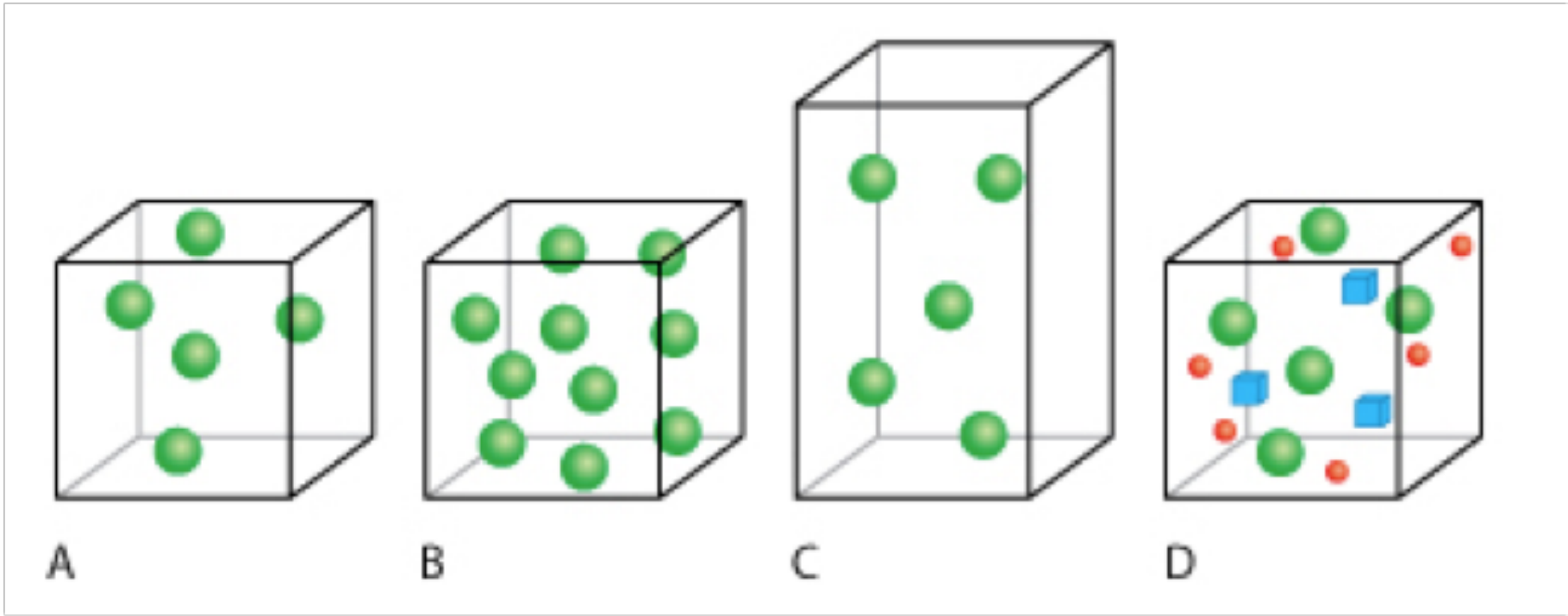
Soda & Scientific Reasoning

Soda	Variable 1	Variable 2	Variable 3	Prediction: Sink or Float?	Observation: Sink or Float	Mass	Density

Soda & Scientific Reasoning

Variable	Prediction	Explanation	Observation

Soda & Scientific Reasoning



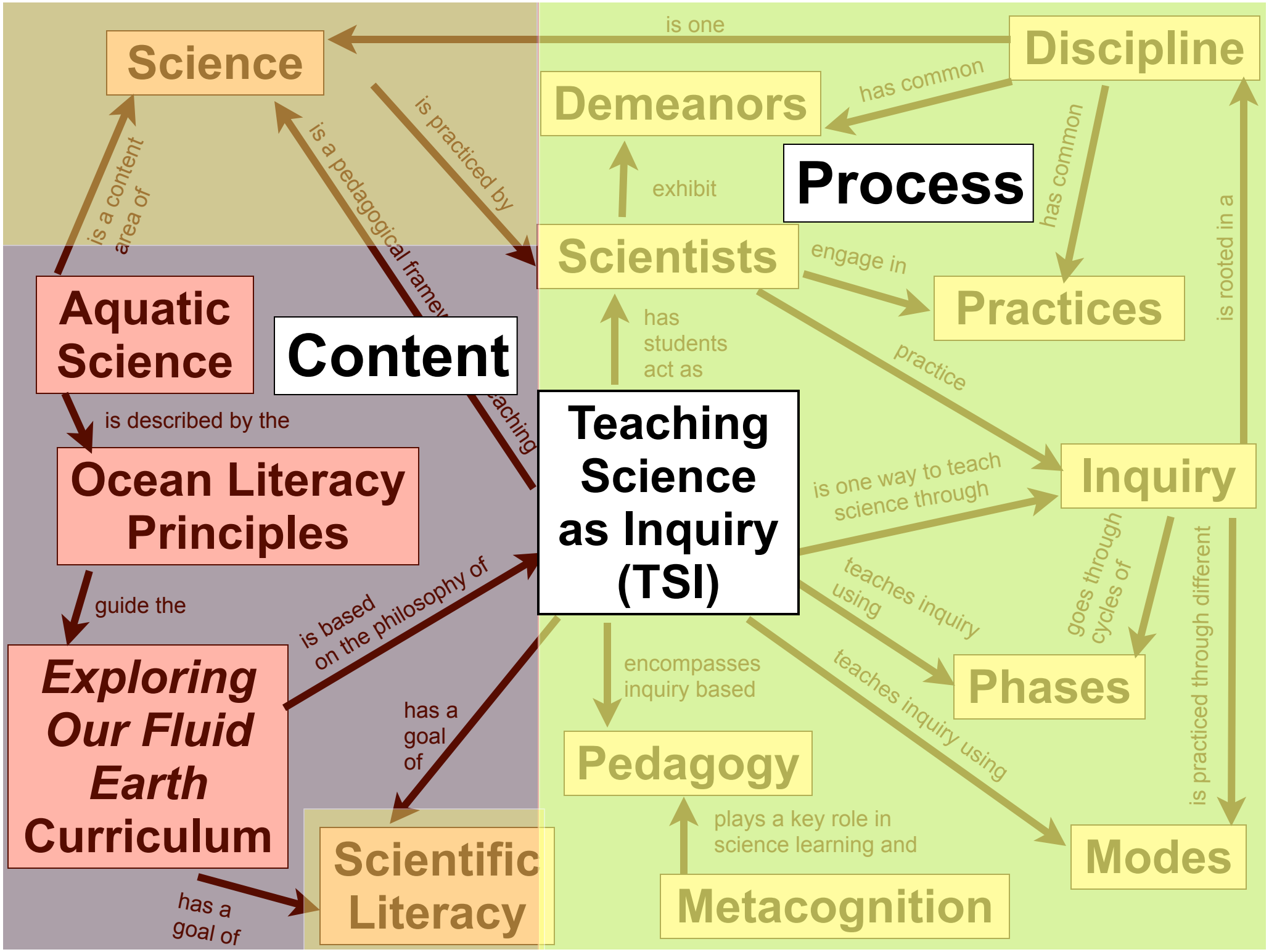
Soda & Scientific Reasoning

Relative Density

Soda & Scientific Reasoning

What characteristics of scientists were you emulating during this activity?

- Science are engaged in the process, or **practices of science**. These are the things scientists actually do.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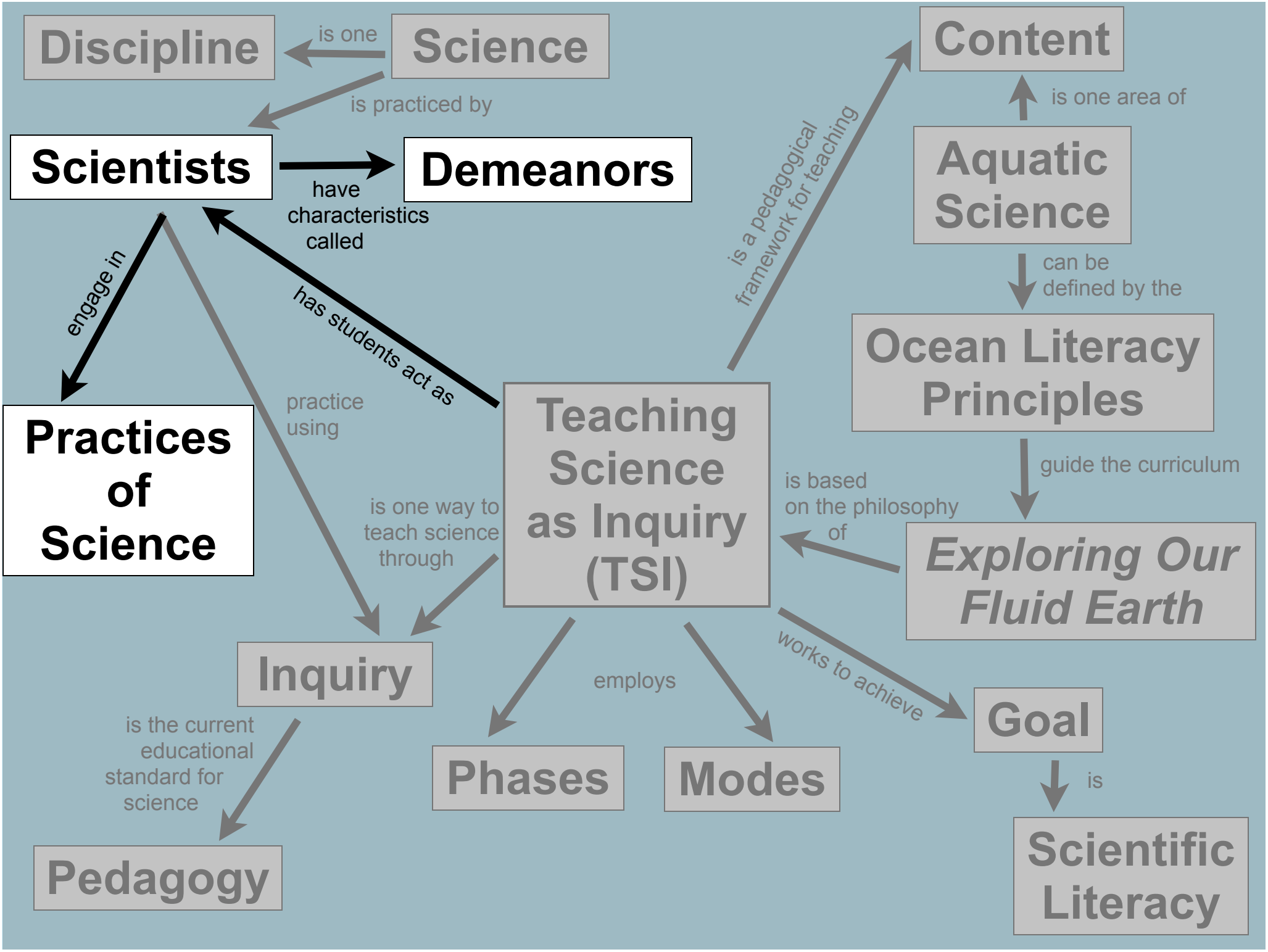
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Practices of Science

Practices of Science:
Things you *actually do* when doing science = verbs

- *Asking* questions
- *Making* observations
- *Devising* a testable hypothesis
- *Collecting, analyzing,* and *interpreting* data
- *Constructing and critiquing* arguments
- *Communicating*

Demeanors:
Adverbs to the practice verbs

- Responsibly
- Courteously
- Skeptically
- Respectfully
- Accurately
- Honestly
- Open-mindedly
- Evidentually

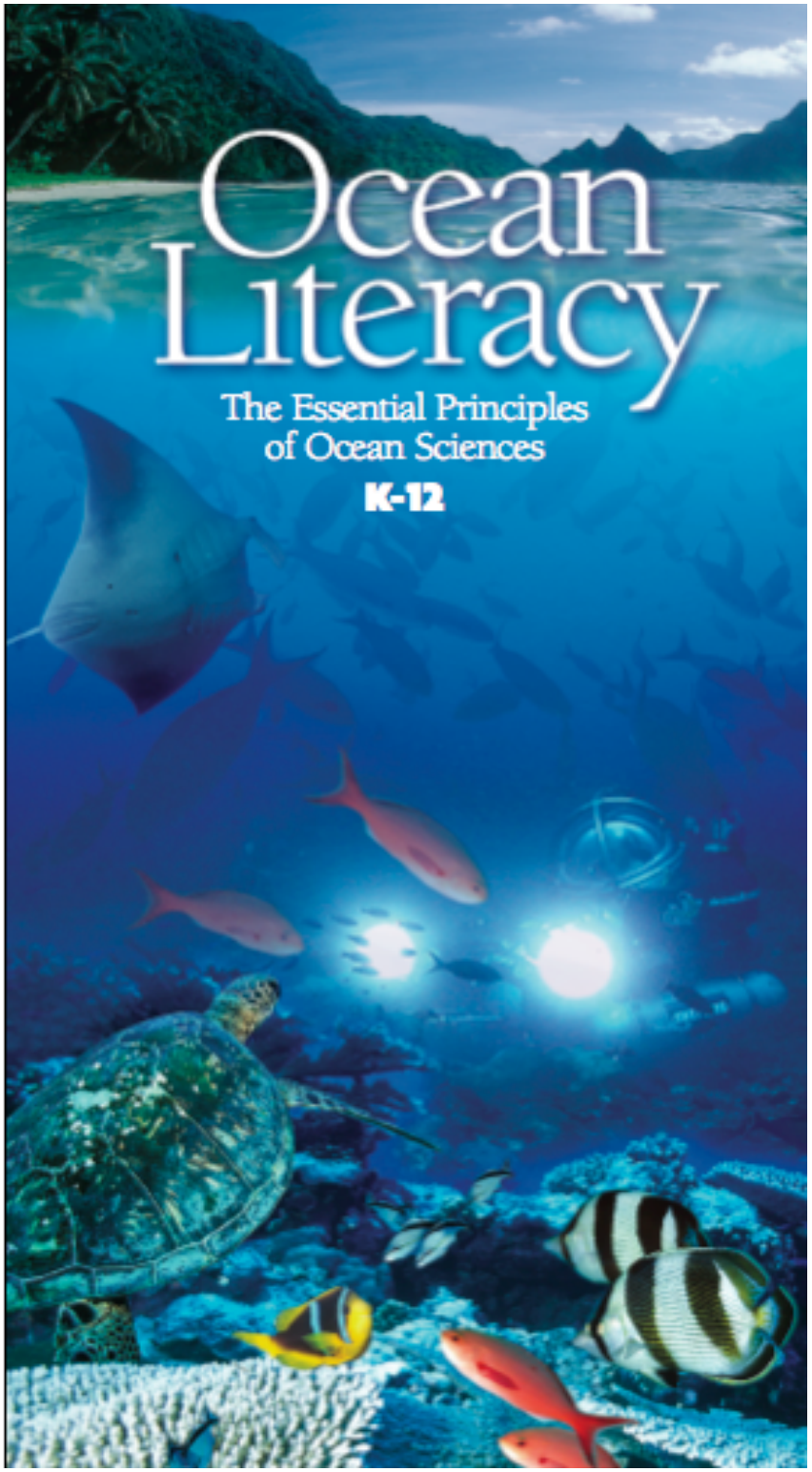
- I am honestly communicating the results of my plant analysis
- We are accurately collecting data by measuring sharks with our meter ruler
- **Create two of your own scientific sentences with a partner.**

Density Bags

Density Bags

Activity Goals

- Determine the effect of temperature and salinity on relative density
- Explain the relationship between floating, sinking and relative density

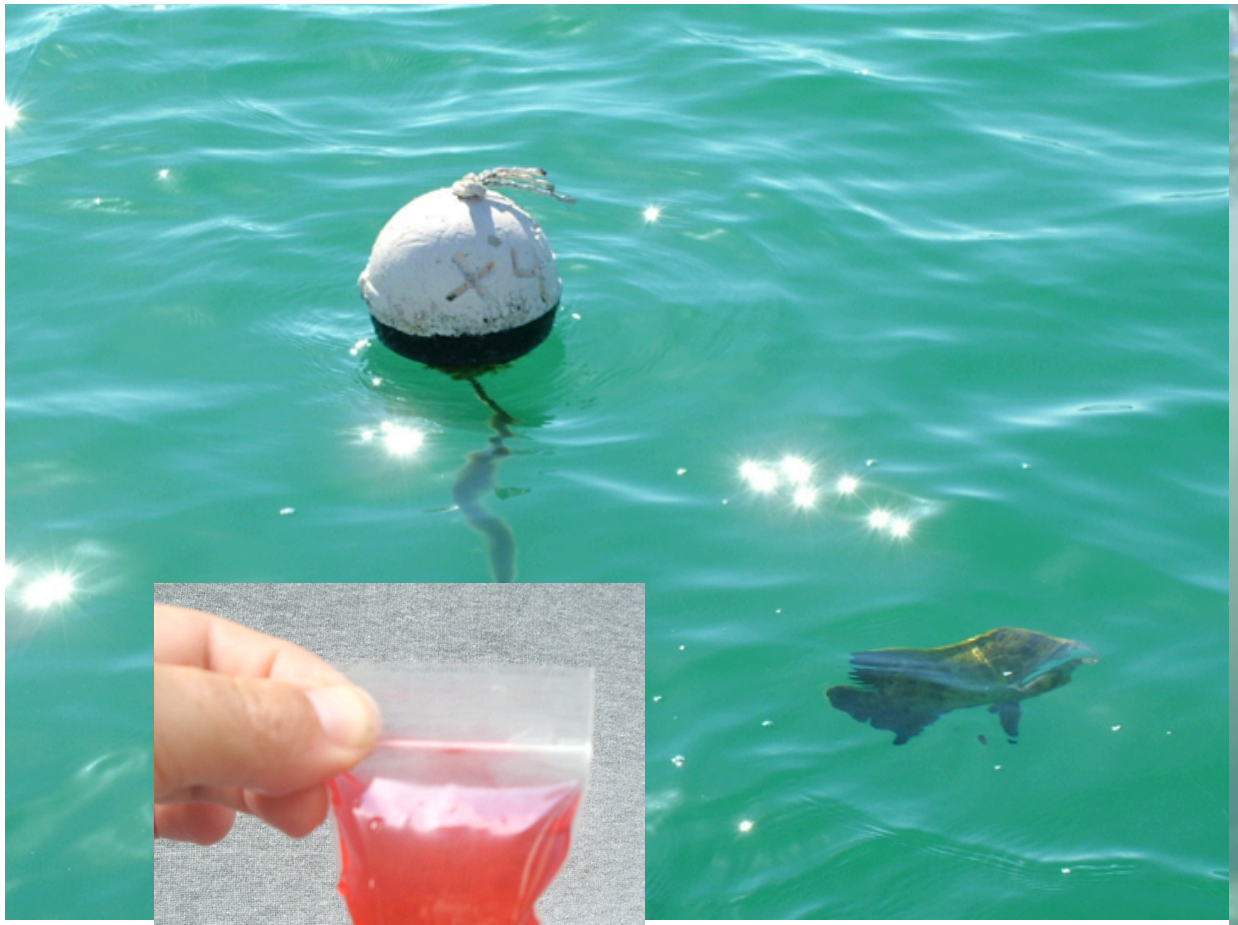


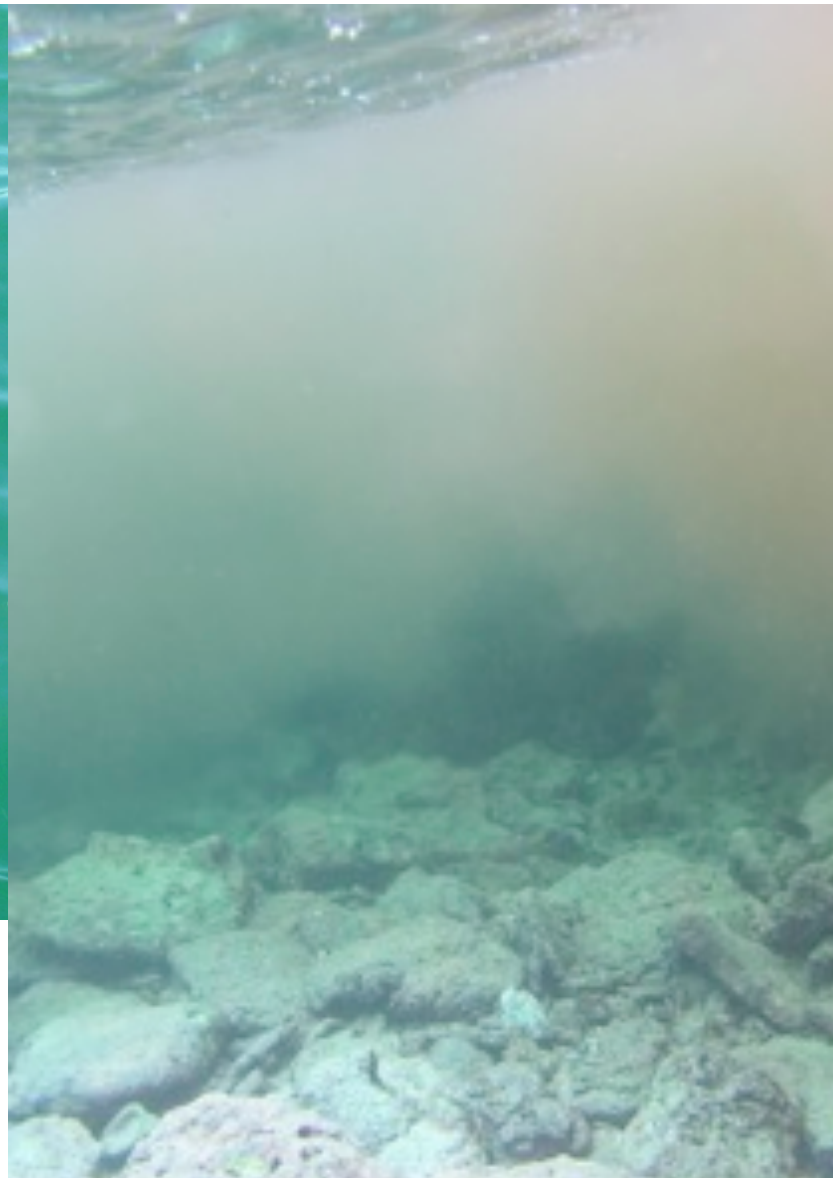
1. Earth has one big ocean with many features.

Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the earth's rotation (Coriolis effect), the sun, and water density differences. The shape of the ocean basins and adjacent landmasses influence the path of circulation. (OLP 1c)

Most of Earth's water (97 percent) is in the ocean. Seawater has unique properties: it is saline, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. The salt in seawater comes from eroding land, volcanic emissions, reactions at the seafloor, and atmospheric deposition. (OLP 1f)

Density Bags





Effect of Salinity (Part A)

- For each combination of fresh and salt water, predict whether the bag will:
    a. sink
    b. float
    c. subsurface float
- Record your predictions in Table 2.1

Filling Bags

- Use a permanent marker to label
- (Optional) Add a drop of food coloring
- Fill using small cup
- Overfill the bag with water using the small cup
- Seal the bag so it does not leak or have air bubbles
- Shake the bag to distribute the food coloring
- Pat the plastic bag dry
- Cut off excess plastic of the bag above the closure

Effect of Salinity

Liquid in beaker	Liquid in bag	
	Fresh water	Salt water
Fresh water	Predicted	Predicted
	Actual	Actual
Salt water	Predicted	Predicted
	Actual	Actual

Effect of Salinity

Liquid in beaker	Liquid in bag	
	Fresh water	Salt water
Fresh water	Predicted	Predicted
	Actual Float (*subsurface*)	Actual Sink
Salt water	Predicted	Predicted
	Actual Float	Actual Float (*subsurface*)

- Compare Results
- Did anyone have subsurface floating?

Effect of Temperature (Part B)

- For each combination of hot and cold fresh water, predict whether the bag will:
    a. sink
    b. float
    c. subsurface float
- Record your predictions in a data table

Effect of Temperature

Liquid in beaker	Liquid in bag	
	Cold water	Hot water
Cold water	Predicted	Predicted
	Actual	Actual
Hot water	Predicted	Predicted
	Actual	Actual

Effect of Temperature

Liquid in beaker	Liquid in bag	
	Cold water	Hot water
Cold water	Predicted	Predicted
	Actual Float (*subsurface*)	Actual Float
Hot water	Predicted	Predicted
	Actual Sink	Actual Float (*subsurface*)

- Compare Results
- Did anyone have subsurface floating?

Effects of Both Salinity & Temperature (Part C)

- Design an experiment to test the effects of both temperature—hot or cold—and salinity—fresh water or salt water—on the rising and sinking of bags of liquid. For example, you might want to determine the relative density of a hot salty water bag in a beaker of cold fresh water.

Temperature & Density
Predicted Results

Liquid in Container	Liquid in bag			
	Cold Salt	Cold Fresh	Hot Salt	Hot Fresh
Cold Salt				
Cold Fresh				
Hot Salt				
Hot Fresh				

Which combinations have we already tested?

Temperature & Density
Predicted Results

Liquid in Container	Liquid in bag			
	Cold Salt	Cold Fresh	Hot Salt	Hot Fresh
Cold Salt				
Cold Fresh		*Float (ss)*		*Float*
Hot Salt				
Hot Fresh		*Sink*		*Float (ss)*

Are there any combinations we can make inferences about given our previous trials?

Temperature & Density
Predicted Results

Liquid in Container	Liquid in bag			
	Cold Salt	Cold Fresh	Hot Salt	Hot Fresh
Cold Salt	Float (ss)	Float	Float	
Cold Fresh	Sink	*Float (ss)*		*Float*
Hot Salt	Sink		Float (ss)	Float
Hot Fresh		*Sink*	Sink	*Float (ss)*

Green underlined = salinity Blue = temperature

Liquid in Container	Liquid in bag			
	Cold Salt	Cold Fresh	Hot Salt	Hot Fresh
Cold Salt	Float (ss)	Float	Float	
Cold Fresh	Sink	*Float (ss)*		*Float*
Hot Salt	Sink		Float (ss)	Float
Hot Fresh		*Sink*	Sink	*Float (ss)*

Green underlined = salinity Blue = temperature

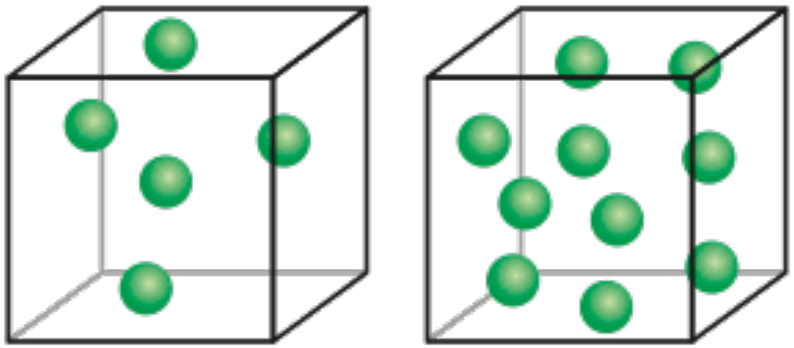
Temperature & Density
Idealized Results

Liquid in Container	Liquid in bag			
	Cold Salt	Cold Fresh	Hot Salt	Hot Fresh
Cold Salt	Float (ss)	Float	Float	Float
Cold Fresh	Sink	*Float (ss)*	Depends	*Float*
Hot Salt	Sink	Depends	Float (ss)	Float
Hot Fresh	Sink	*Sink*	Sink	*Float (ss)*

Green underlined = salinity Blue = temperature

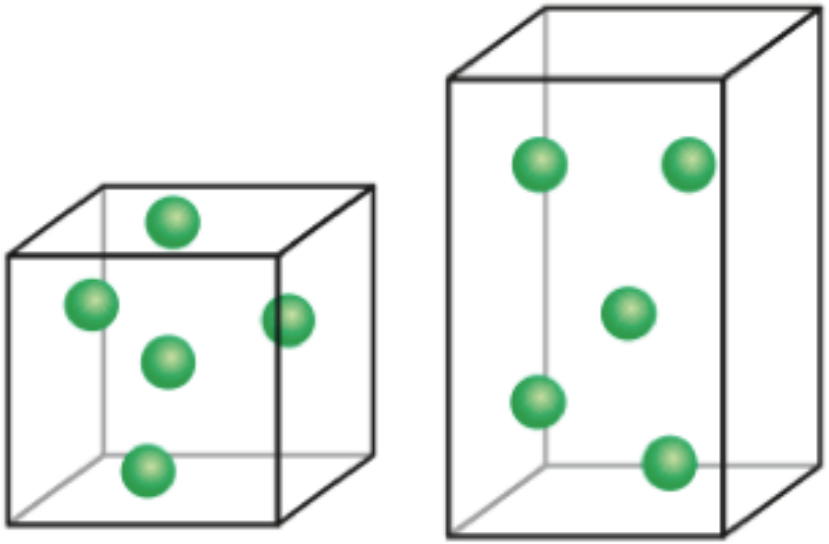
Density Bags

Increase in salinity



A B

Increase in temperature

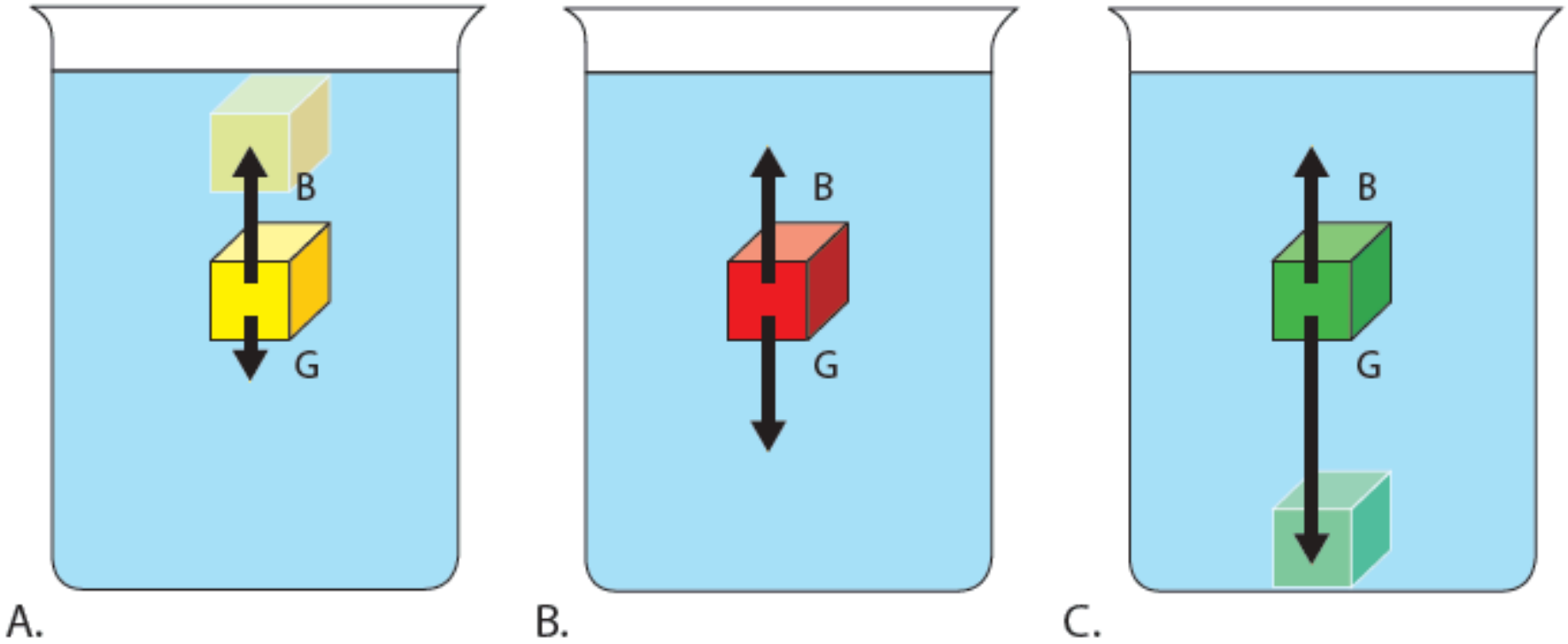


A C

Density, Temperature, and Salinity

Gravitational force (G) & Buoyant force (B)

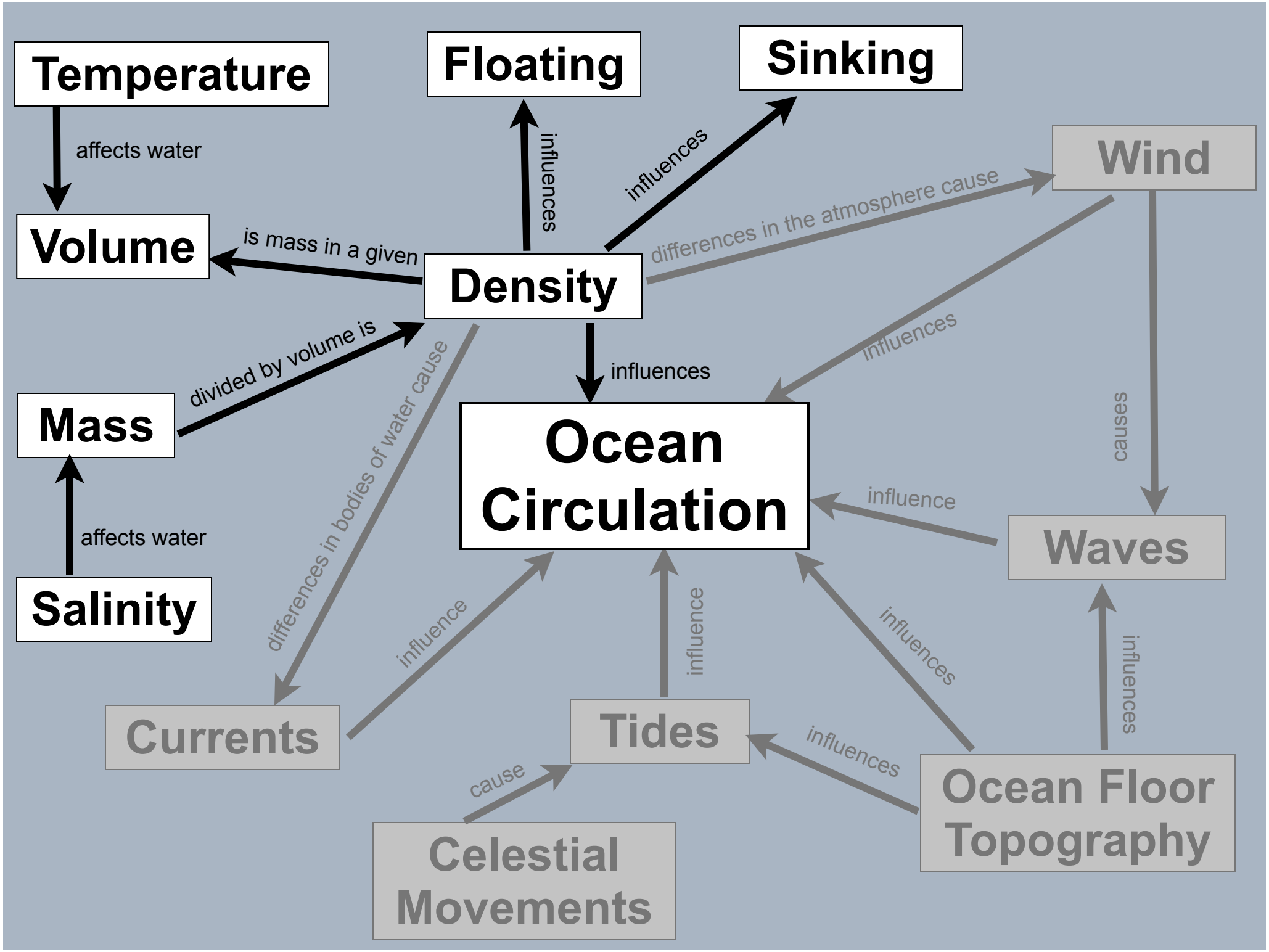
Three cubes with different densities



A. G < B

B. G = B

C. G > B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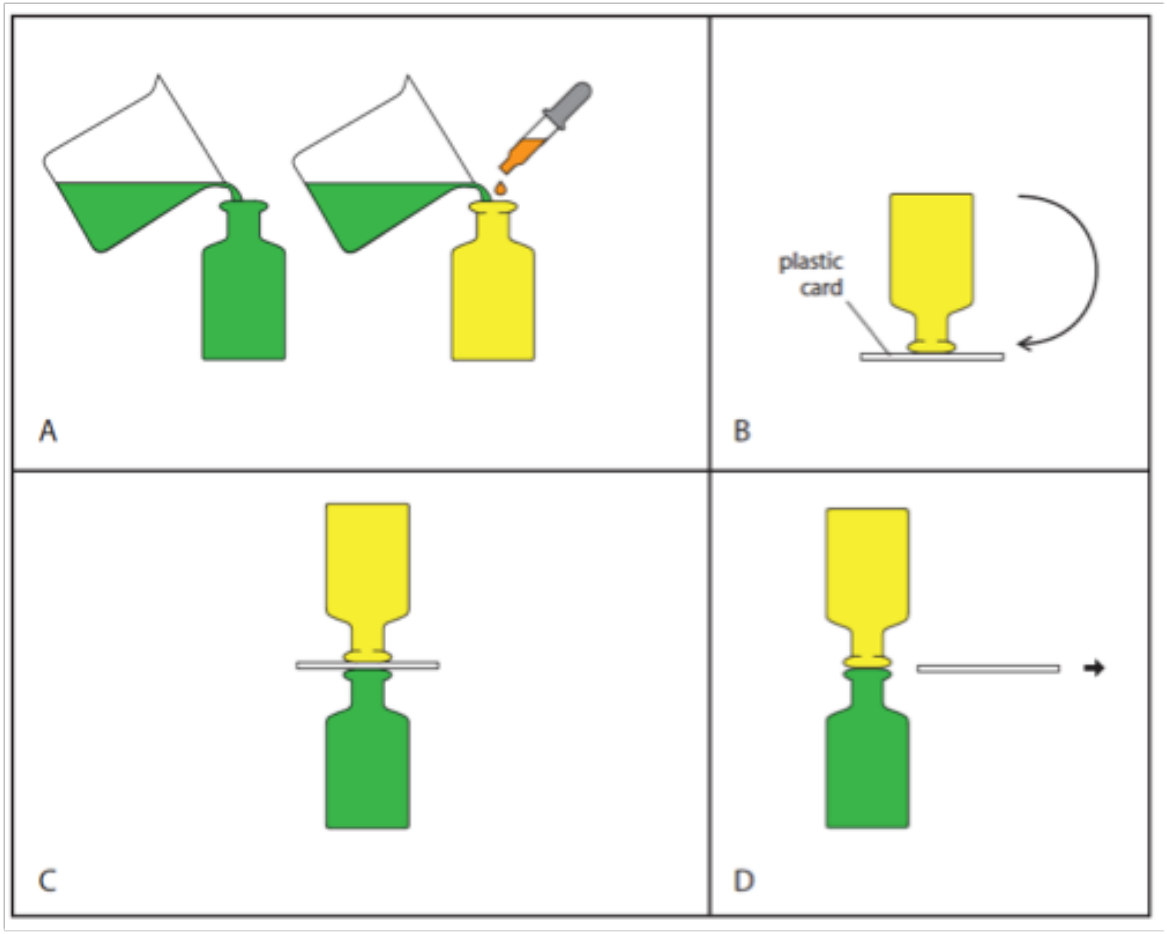
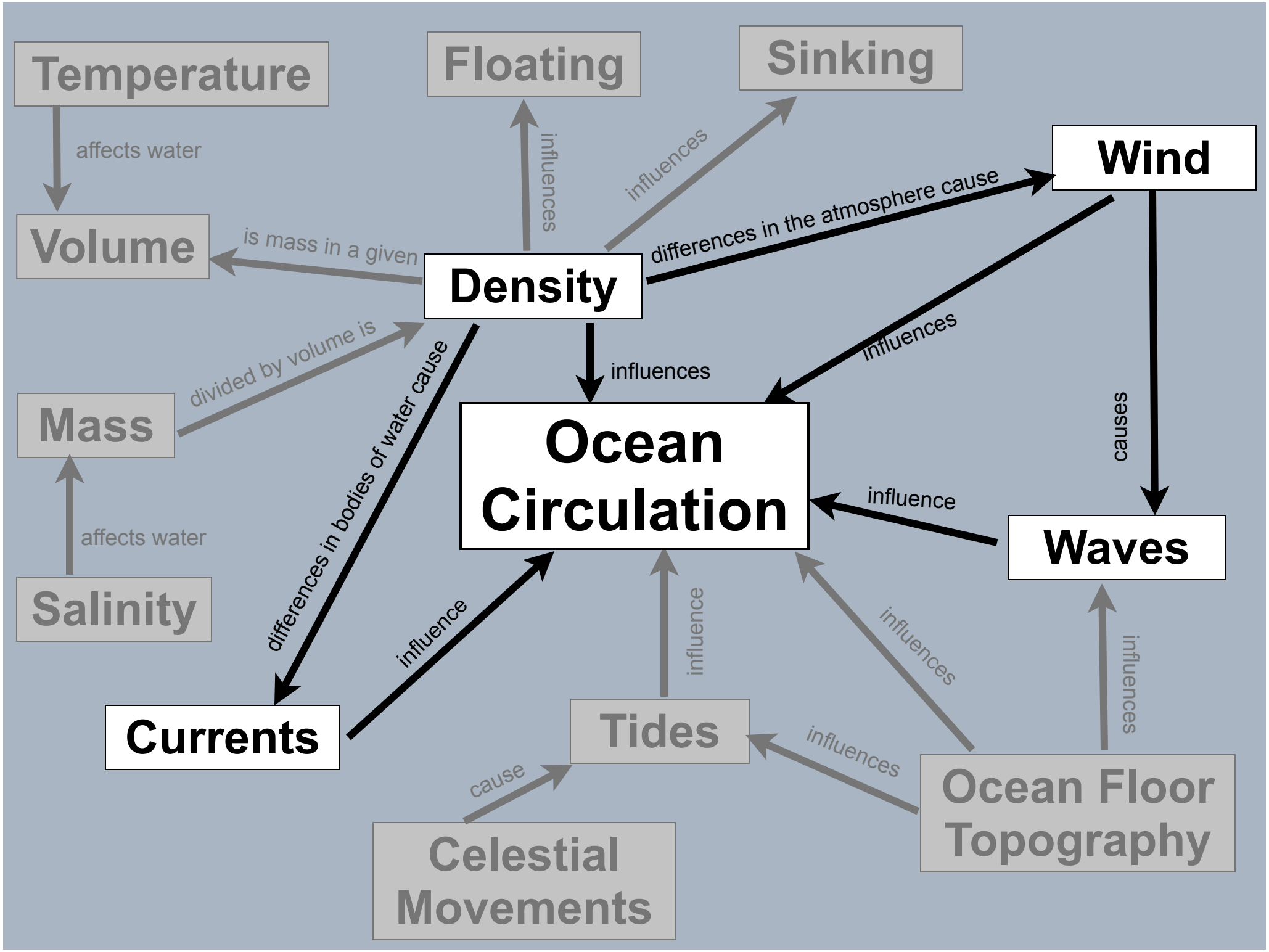
Celestial Movements

Gravitational Currents

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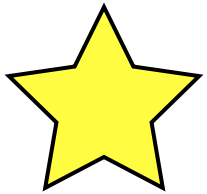
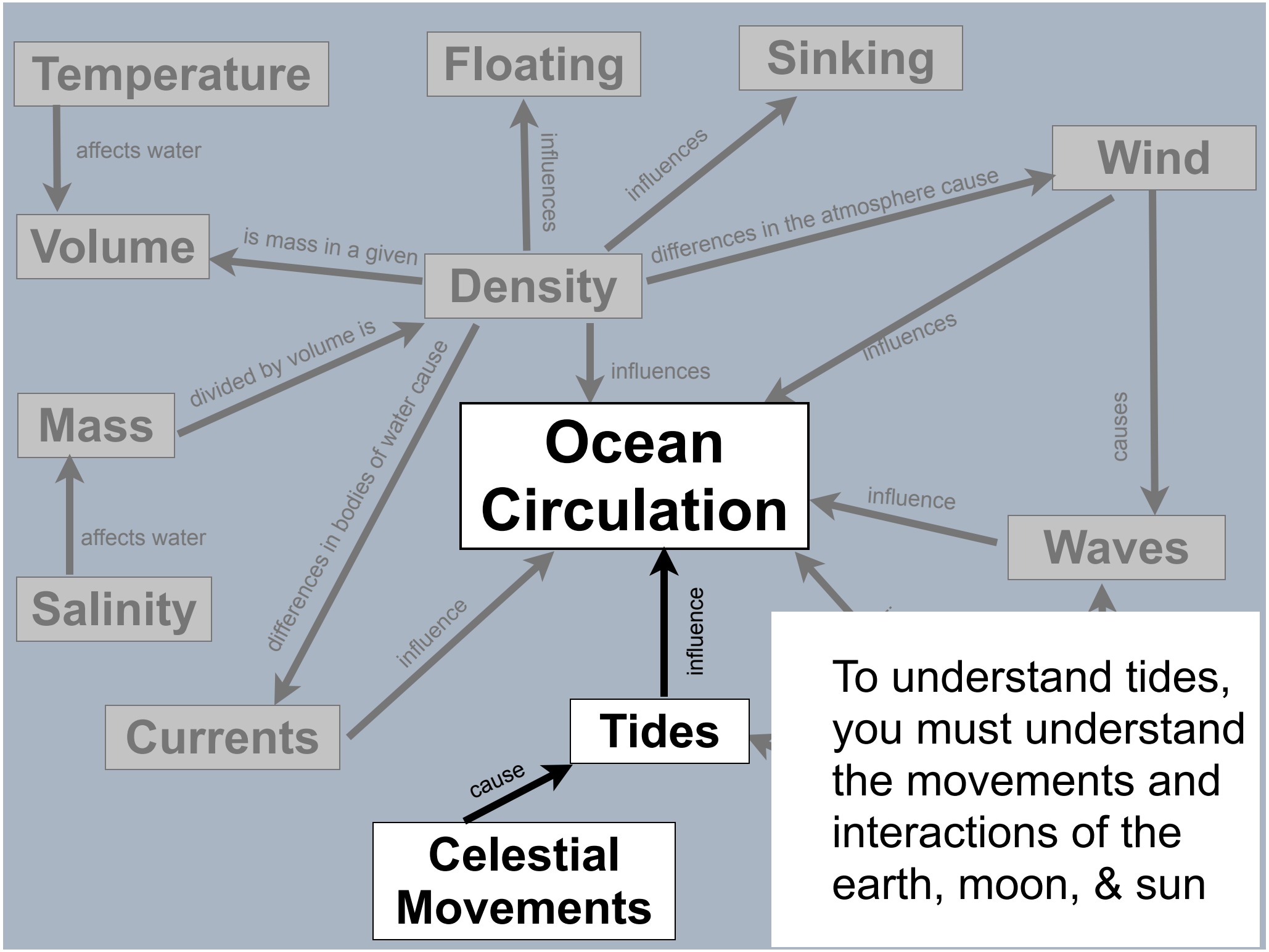
Kinesthetic Model of the Sun, Moon, and Earth



Tides

Tides

Tides are waves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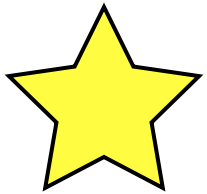
influence
Waves
influence
influence
Currents
Tides
cause
Celestial Movements
To understand tides, you must understand the movements and interactions of the earth, moon, & sun

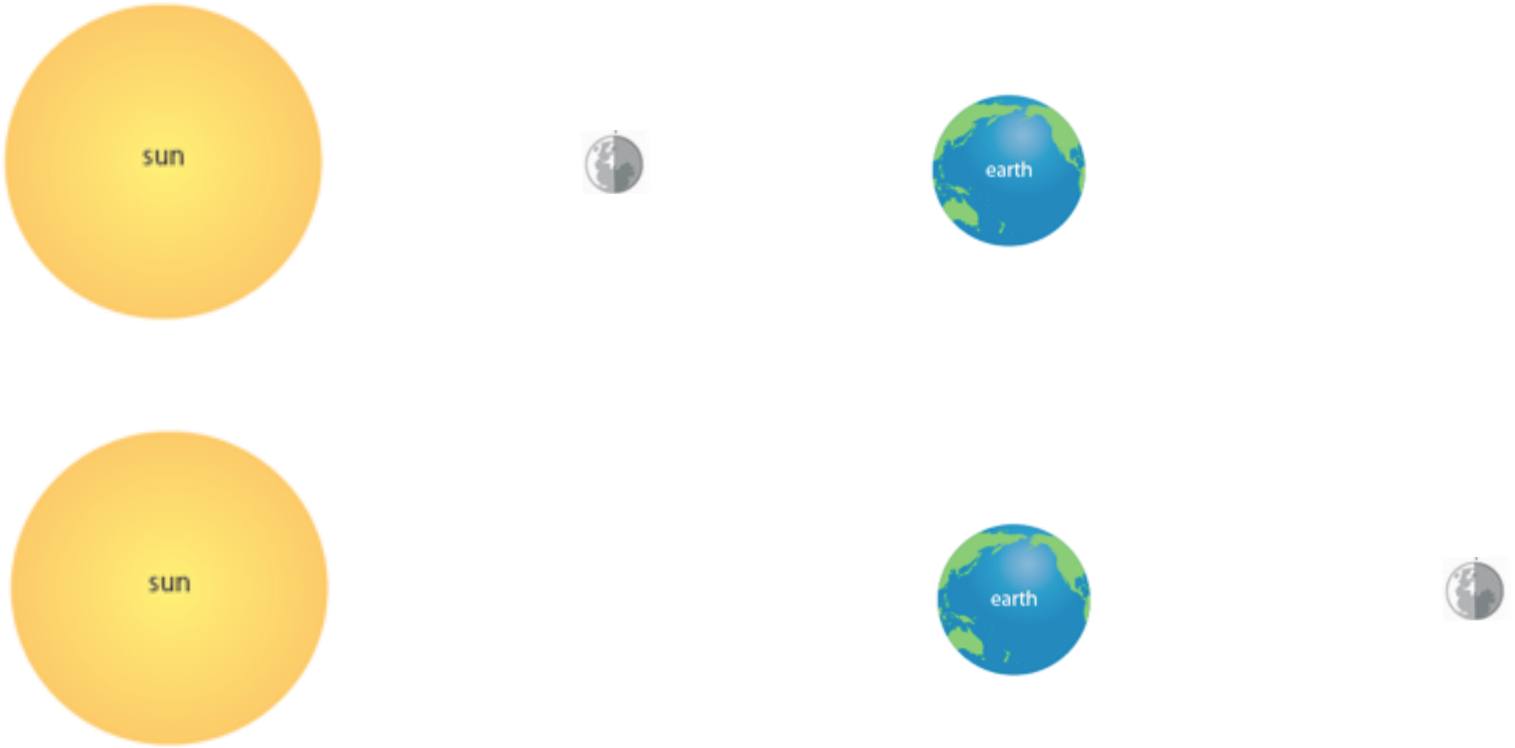
Kinesthetic Moon Model



Activity Goals

- Explore and address misconceptions about the movements of the sun, earth and moon

Spring Tides



Neap Tides