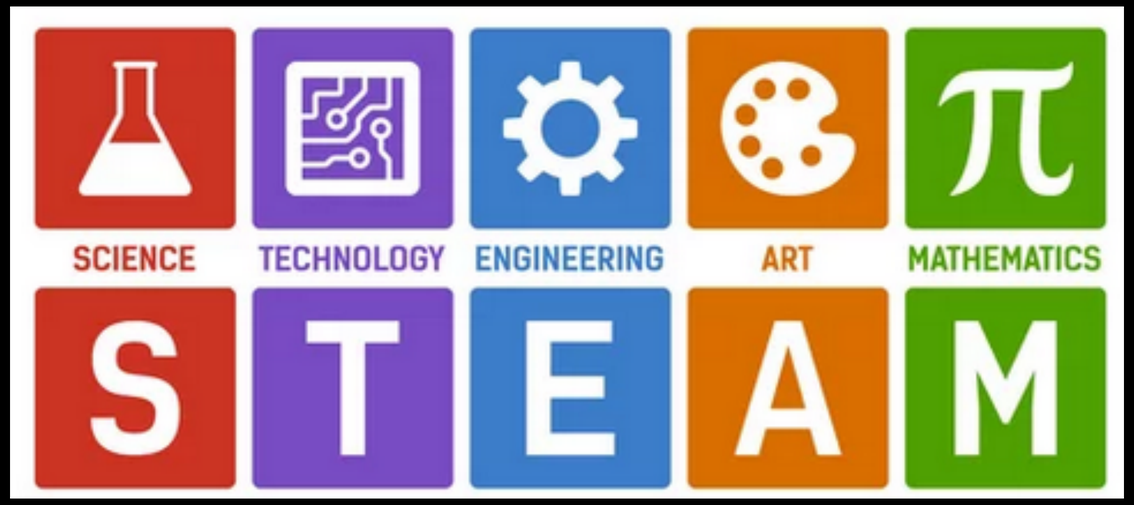
Patterns

Cause
Effect

Scale
Proportion
Quantity

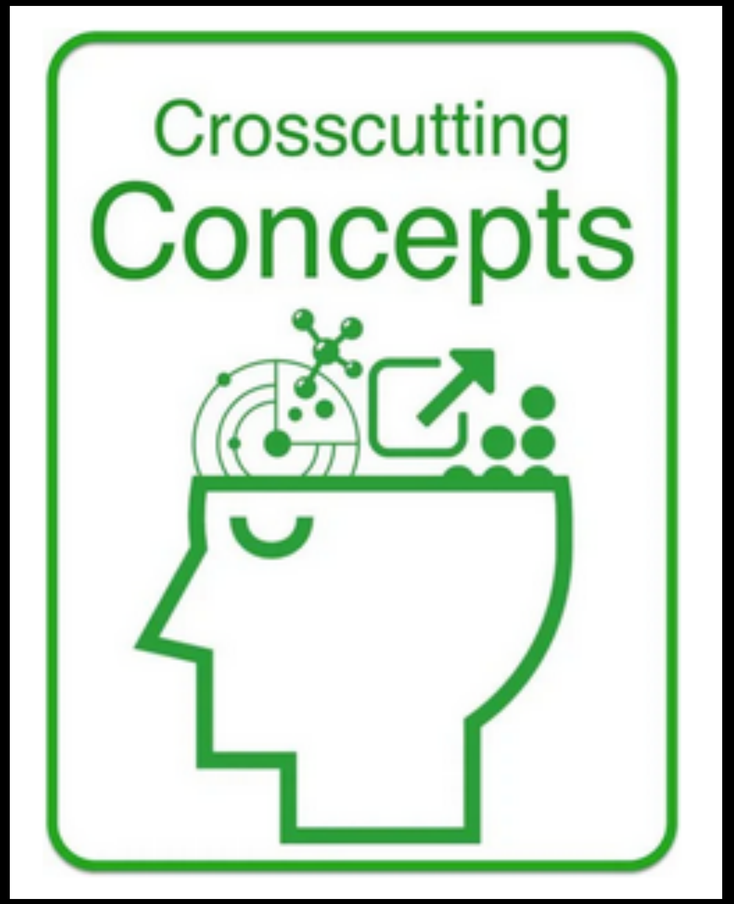
Stability
Change



Systems
System Models

Structure
Function

Energy
Matter



Patterns
Cause & Effect: Mechanism & Explanation
Scale, Proportion, & Quantity
Systems & System Models
Energy & Matter: Flow, Cycle, Conservation
Structure & Function
Stability & Change

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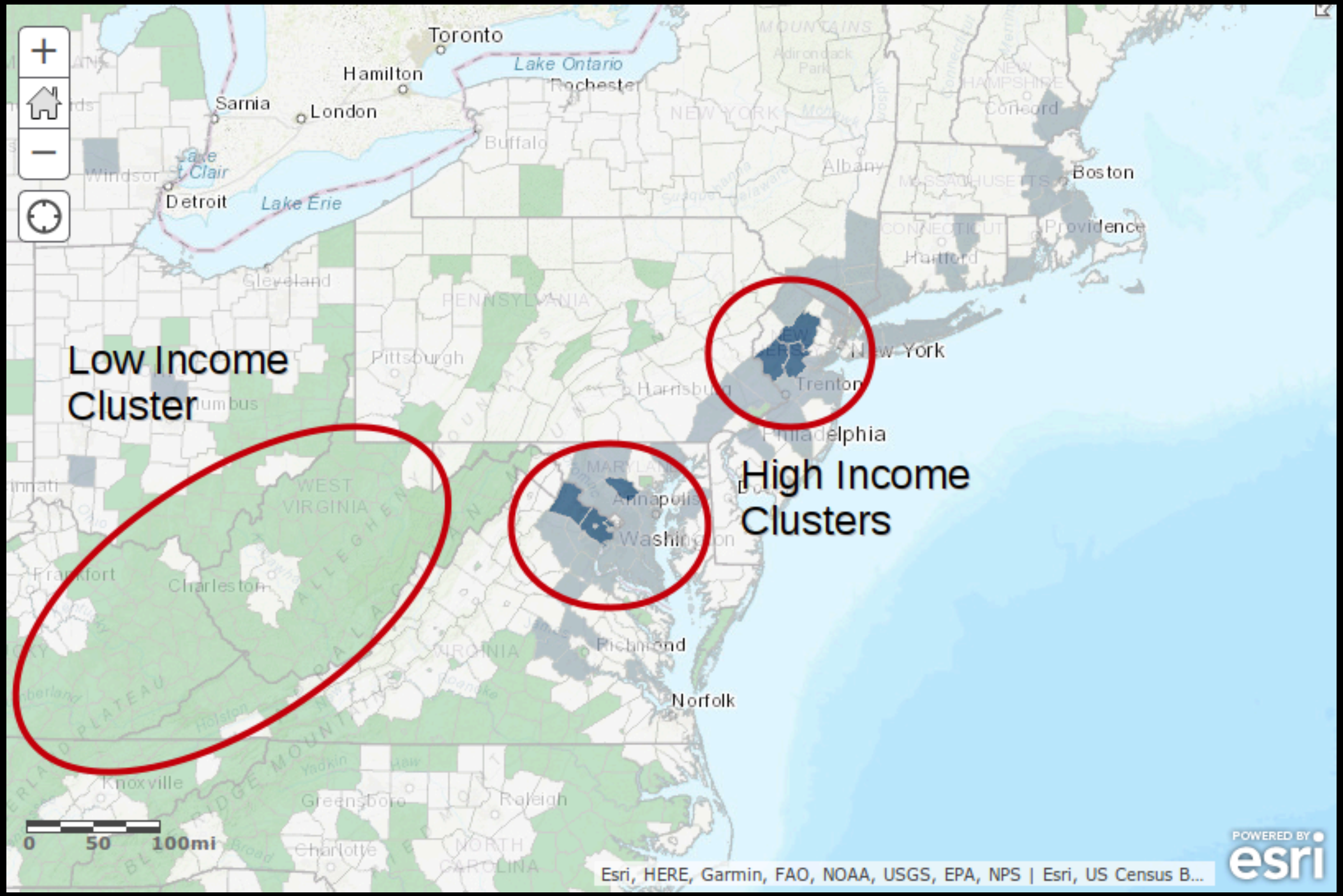
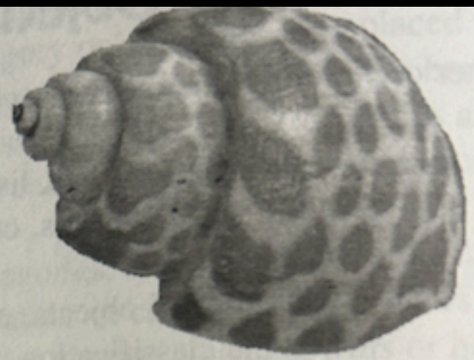

Low Income Cluster
High Income Clusters
Toronto
Hamilton
Lake Ontario
Rochester
Sarnia
London
Buffalo
Albany
Boston
Providence
Hartford
Detroit
Lake Erie
Cleveland
Pittsburgh
New York
Trenton
Harrisburg
Philadelphia
Annapolis
Washington
Charleston
Richmond
Norfolk
Knoxville
Greensboro
Raleigh
Charlotte
0 50 100mi
Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS | Esri, US Census B...
POWERED BY esri

Classification

1

2



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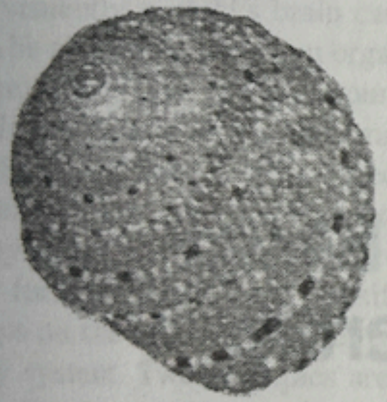

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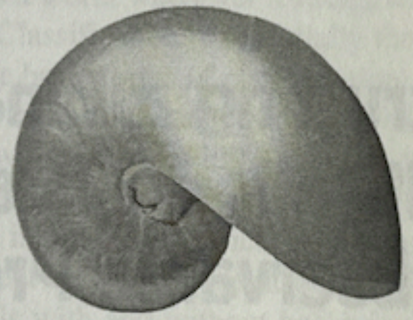
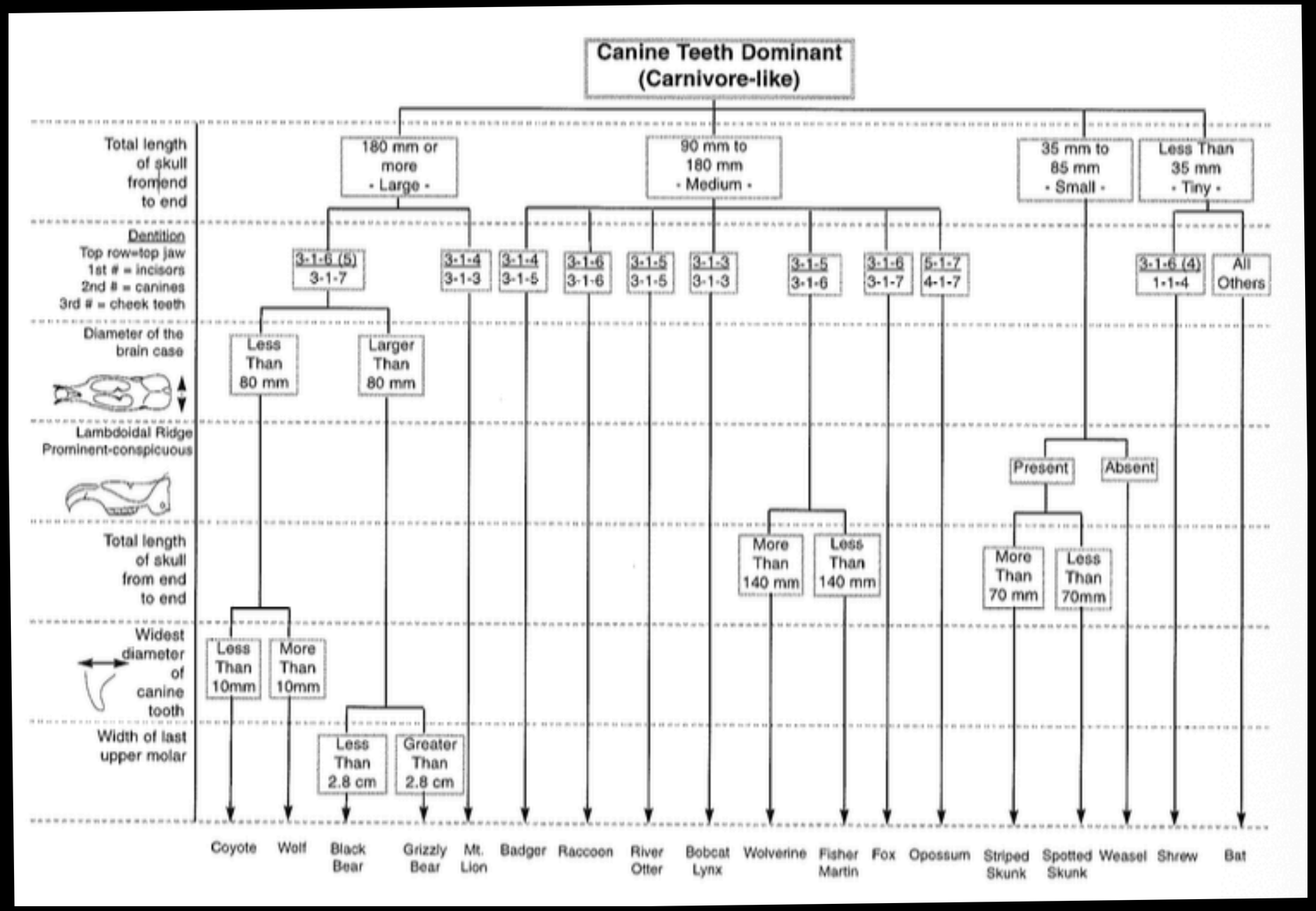


5

6

Observable Properties	Yes	No
1. has dark spots	3, 4	1, 2, 5, 6

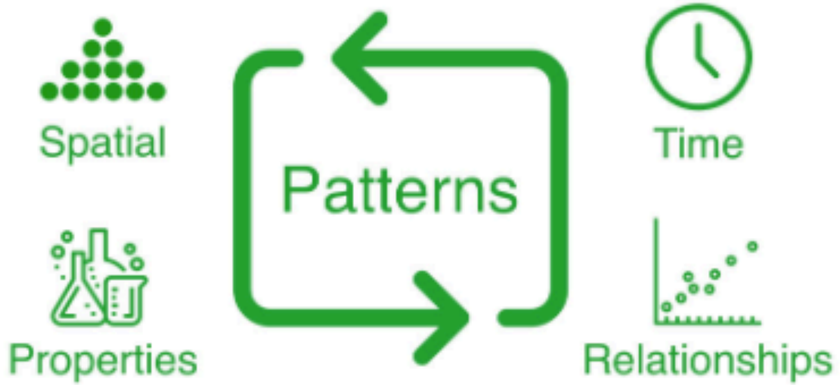

Canine Teeth Dominant
(Carnivore-like)
Total length of skull from end to end
180 mm or more - Large -
90 mm to 180 mm - Medium -
35 mm to 85 mm - Small -
Less Than 35 mm - Tiny -
Dentition
Top row=top jaw
1st # = incisors
2nd # = canines
3rd # = cheek teeth
3-1-6 (5) 3-1-7
3-1-4 3-1-3
3-1-4 3-1-5
3-1-6 3-1-6
3-1-5 3-1-5
3-1-3 3-1-3
3-1-5 3-1-6
3-1-6 3-1-7
5-1-7 4-1-7
3-1-6 (4) 1-1-4
All Others
Diameter of the brain case
Less Than 80 mm
Larger Than 80 mm
Lambdoidal Ridge Prominent-conspicuous
Present
Absent
Total length of skull from end to end
More Than 140 mm
Less Than 140 mm
More Than 70 mm
Less Than 70mm
Widest diameter of canine tooth
Less Than 10mm
More Than 10mm
Width of last upper molar
Less Than 2.8 cm
Greater Than 2.8 cm
Coyote
Wolf
Black Bear
Grizzly Bear
Mt. Lion
Badger
Raccoon
River Otter
Bobcat Lynx
Wolverine
Fisher Martin
Fox
Opossum
Striped Skunk
Spotted Skunk
Weasel
Shrew
Bat

Patterns

Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Framing Questions

- What structures or shapes are found in the phenomenon or system after careful observation?
- What cycles or events repeat over time?
- How could these patterns be represented?
- How could patterns be used to classify or organize objects and events?
- What causal relationships are found in the data?



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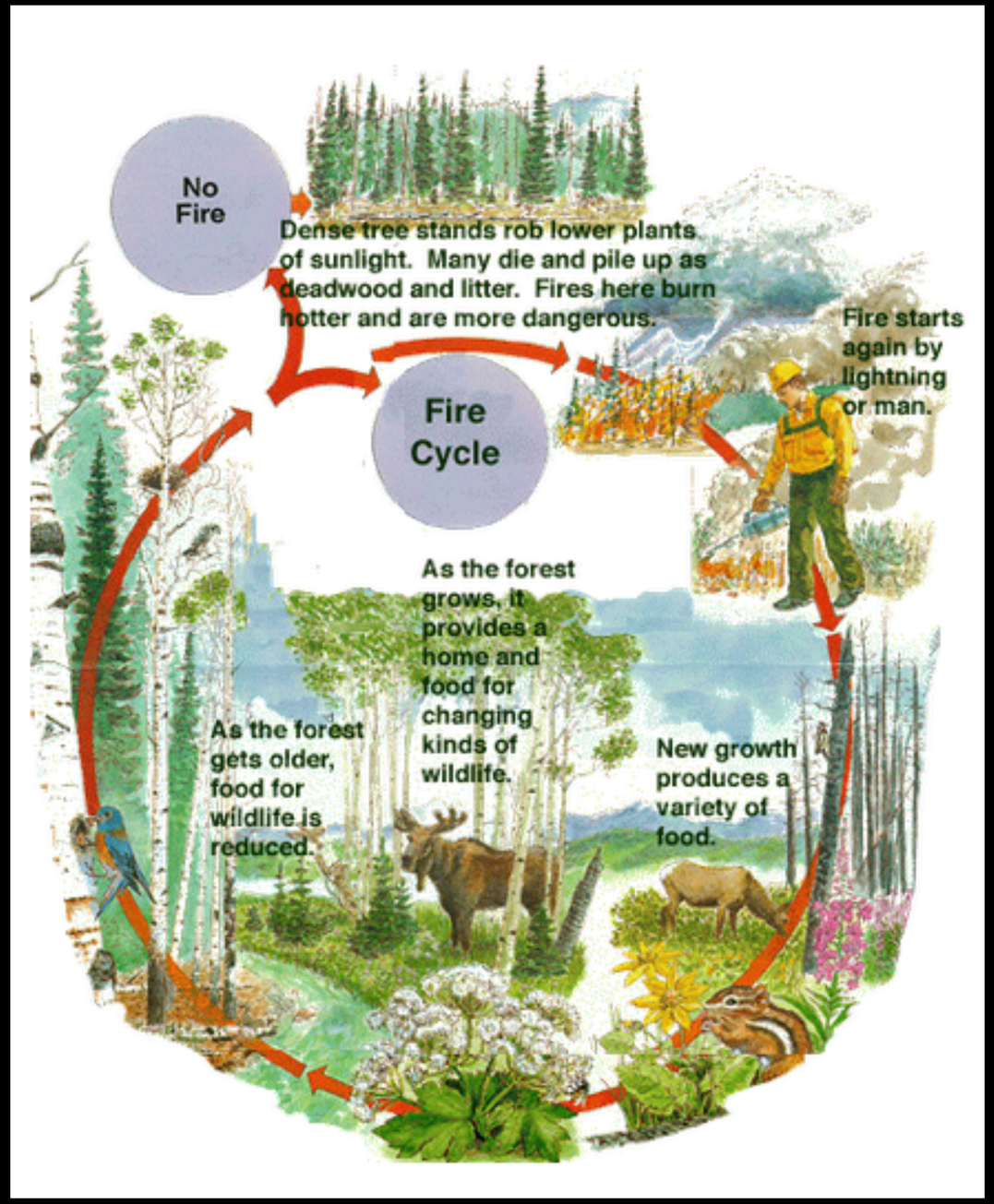

https://blogs.tuni.fi/enve/blogpost/wildfires-natures-ally-who-became-an-enemy/


Kokanee Spawning - Color Plate
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Kokanee Spawning - Color Plate
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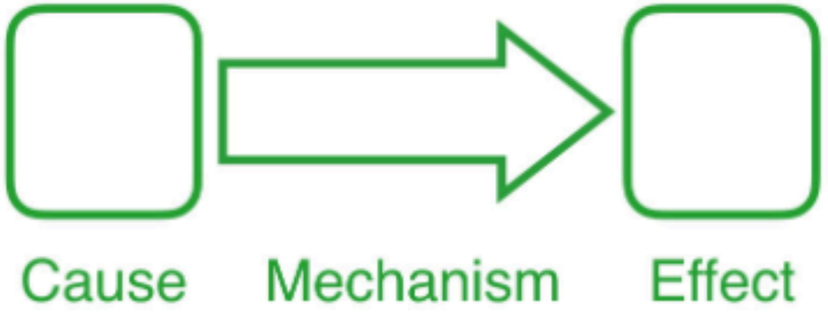
Kokanee Spawning - Color Plate

Cause and Effect

Events have causes, sometimes simple, sometimes multifaceted. Correlation does not imply causation.

Framing Questions

- What relationships between events or patterns can be observed in the phenomenon or system?
- How can these relationships be explained?
- Are any of these relationships cause and effect?
- What evidence supports a cause and effect relationship?
- What further investigations would help determine if these relationships are cause and effect?



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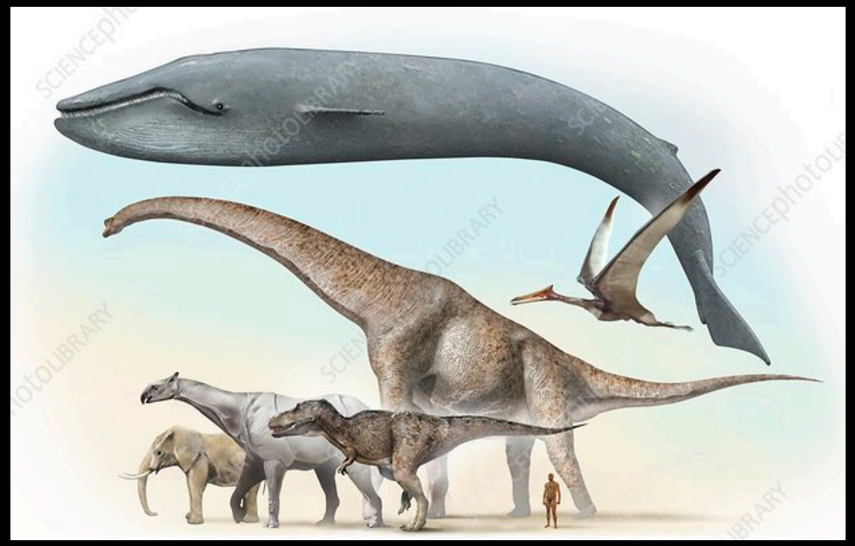
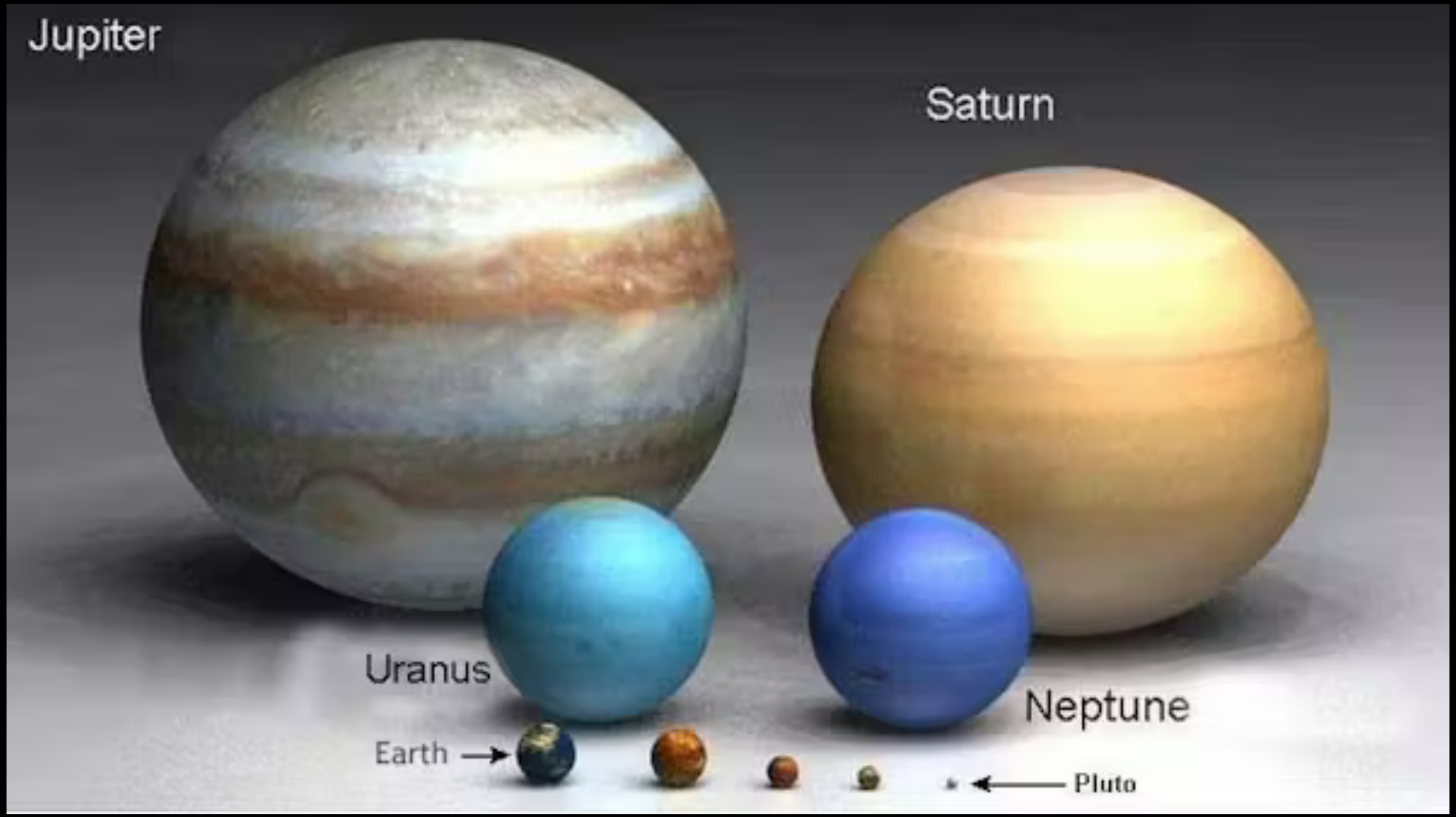



Jupiter
Saturn
Uranus
Neptune
Earth
Pluto

1 dot

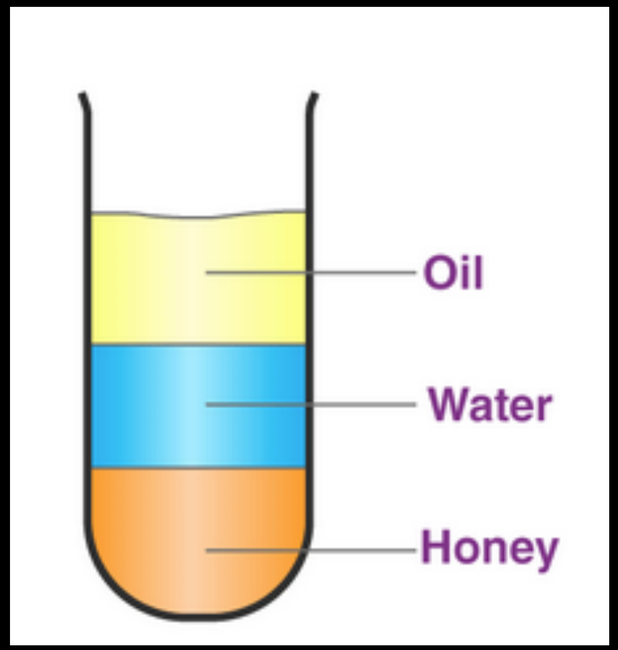
10 dots

100 dots

1000 dots

10,000 dots

100,000 dots



Density=mass/volume

Proportion/Ratios

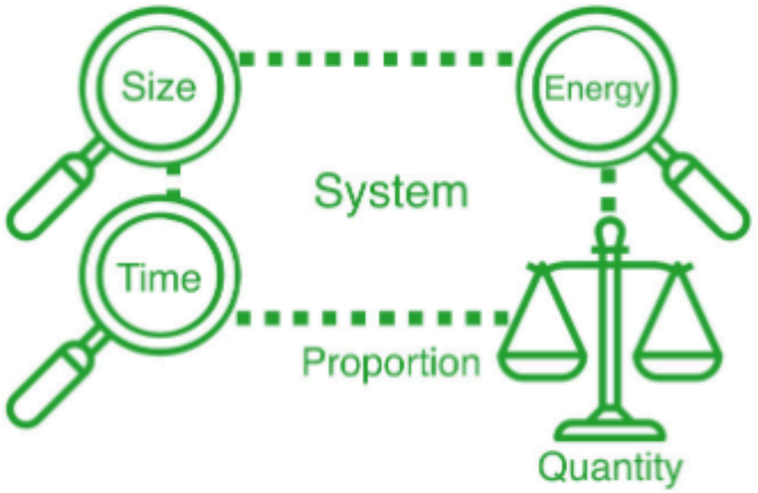
Parts per million

Scale, Proportion, and Quantity

It is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

Framing Questions

- What aspects of the system may be relevant at different time, size, and energy scales?
- How do different quantities vary at different scales?
- What measurements could be made to describe the system more precisely?
- What proportional relationships can be observed?



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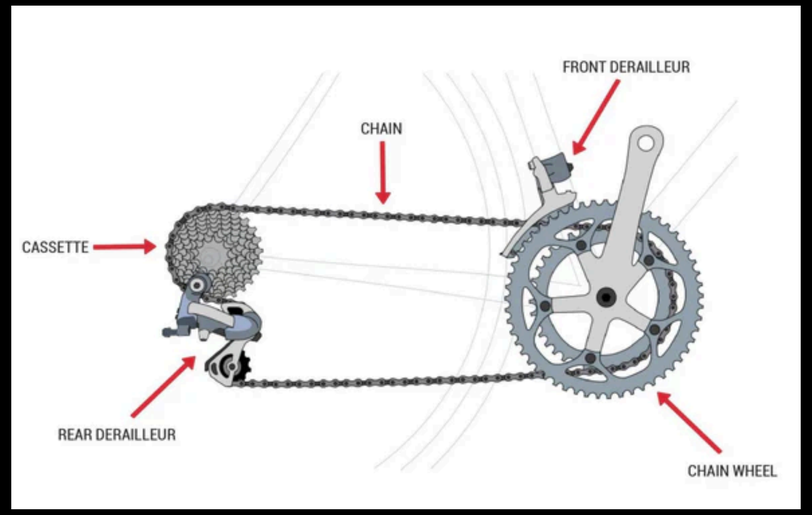
Boundaries
Inputs
Energy/Matter
Outputs


handle bar and grips
seat/saddle
stem
seat post
fork
chain guard
spokes
rim
tire
crank
crank arm
pedal

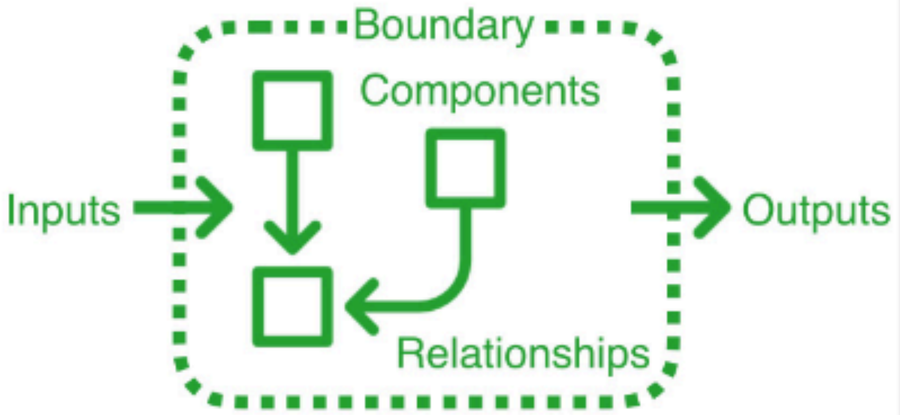

FRONT DERAILLEUR
CHAIN
CASSETTE
REAR DERAILLEUR
CHAIN WHEEL

Systems and System Models

A system is an organized group of related objects or components. Models can be used for understanding and predicting the behavior of systems.

Framing Questions

- What is included in the system? What is external?
- What are the components of the system and how are they related?
- What are the inputs and outputs of the system?
- What predictions can be made from a system model?
- What are the limits of the system model?



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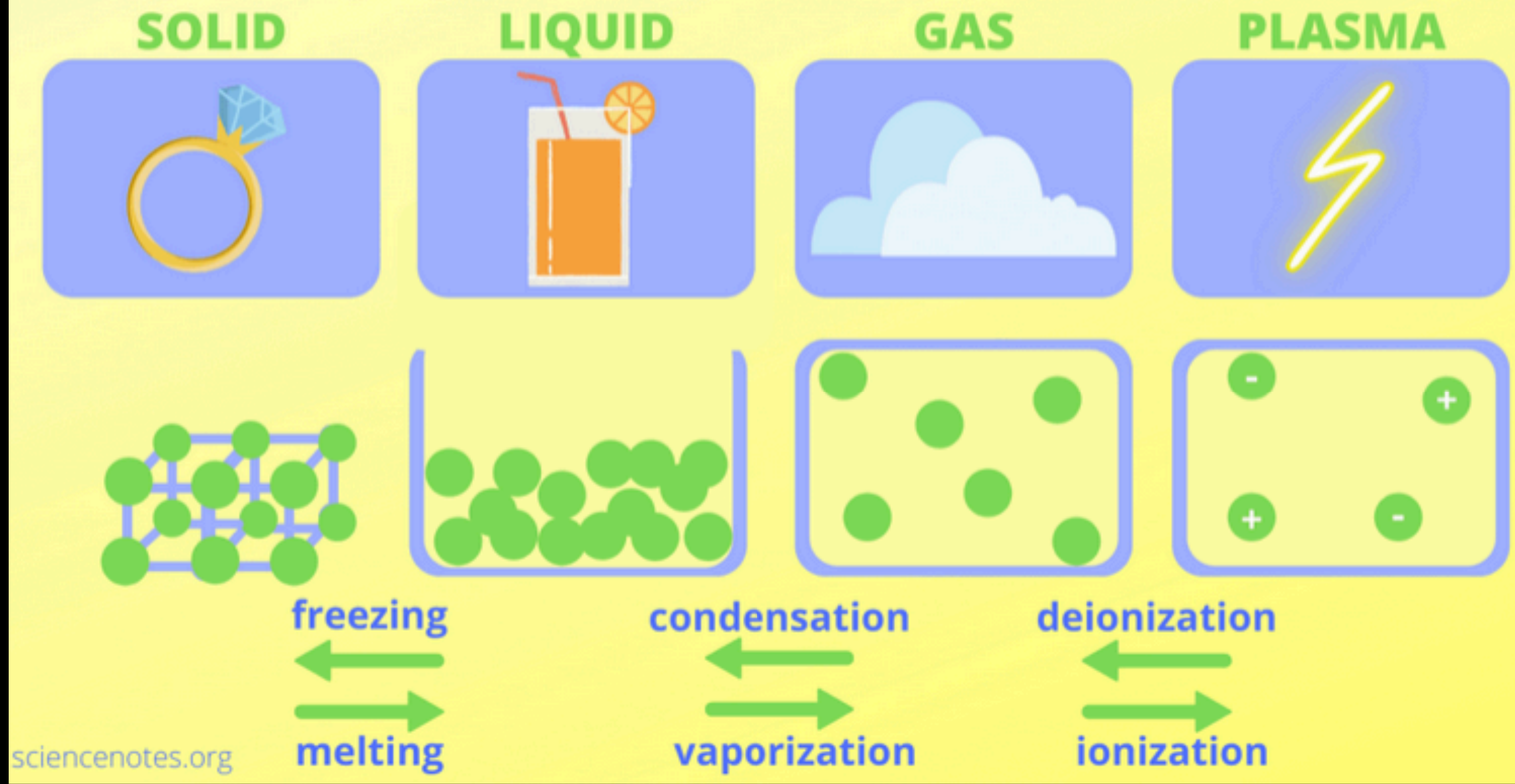
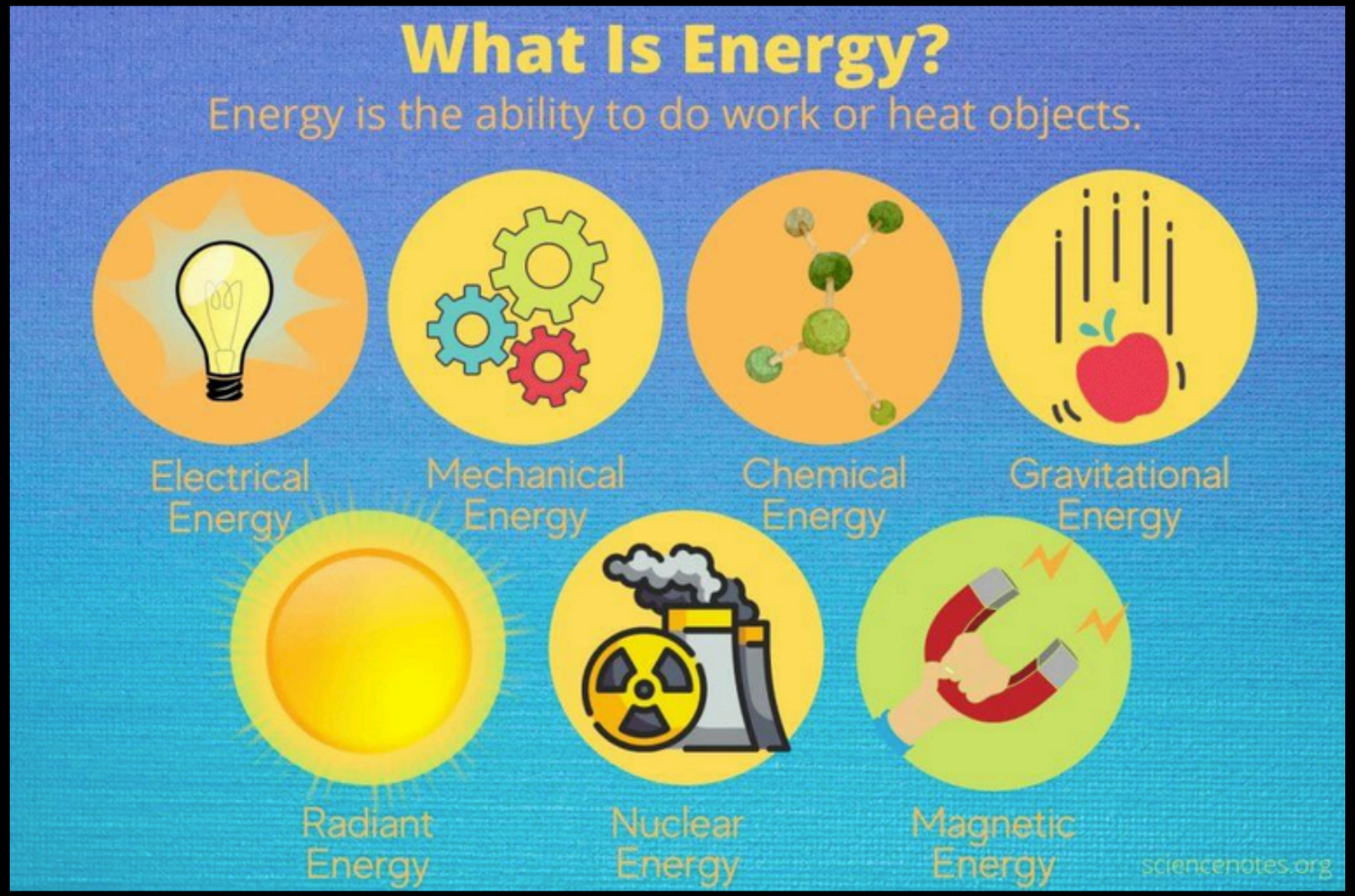
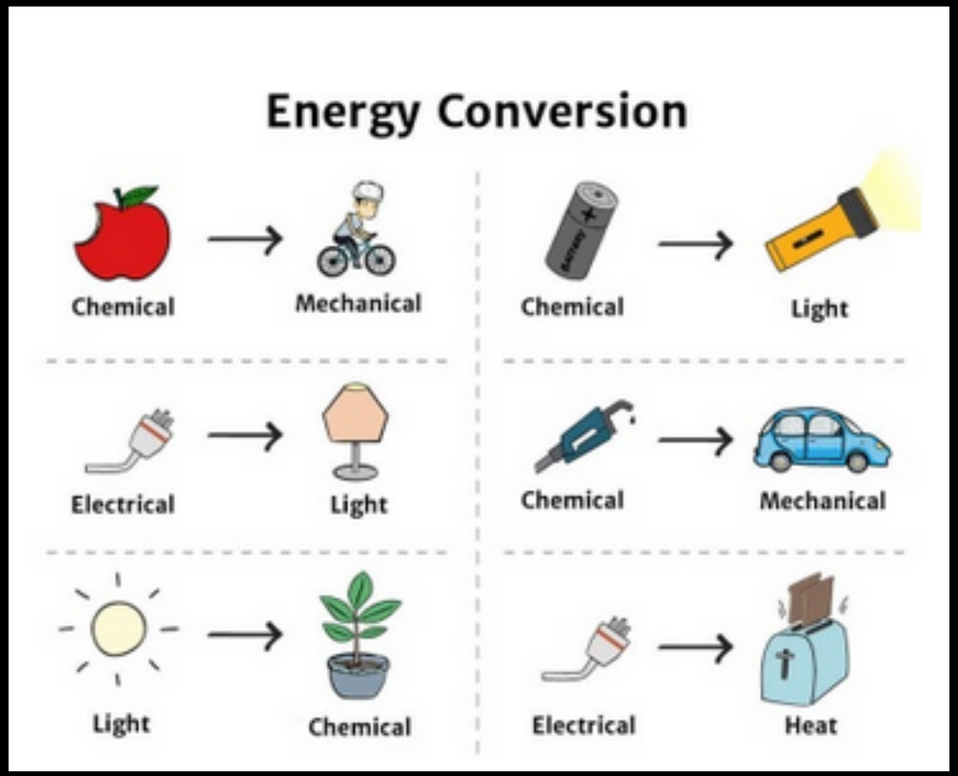
What Is Matter?

Matter is anything that has mass and takes up space.





https://sciencenotes.org/energy-definition-examples/



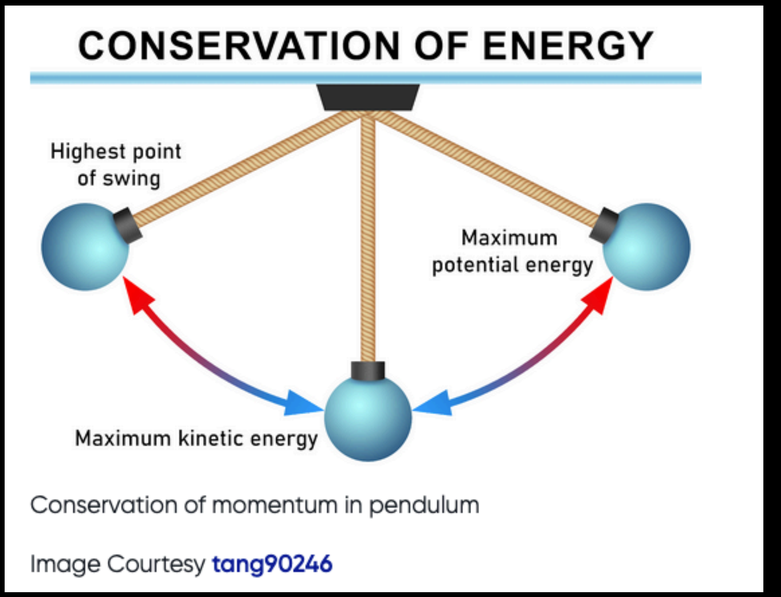
https://solarschools.net/knowledge-bank/energy/conversion

Law of Conservation of Matter (Mass)

Regardless of how substances within a closed system are changed, the **total mass remains the same.**

Law of Conservation of Energy

Energy cannot be created or destroyed but only changed from one form to another.



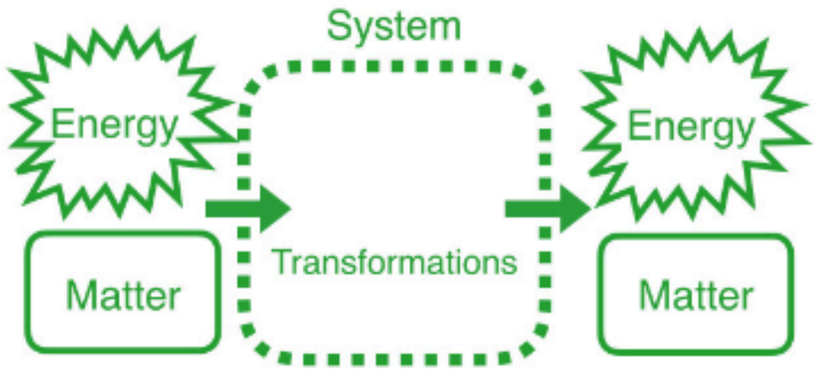
https://www.tutorchase.com/notes/ib/physics-2025/1-3-1-conservation-of-energy

Energy and Matter

Tracking energy and matter flows, into, out of, and within systems.

Framing Questions

- What matter flows into, out of, and within the system?
- What physical and chemical changes occur in the system?
- What transformations of energy are important in the system?
- How does the flow of energy drive the movement of matter in the system?
- How are energy and matter conserved in the system?



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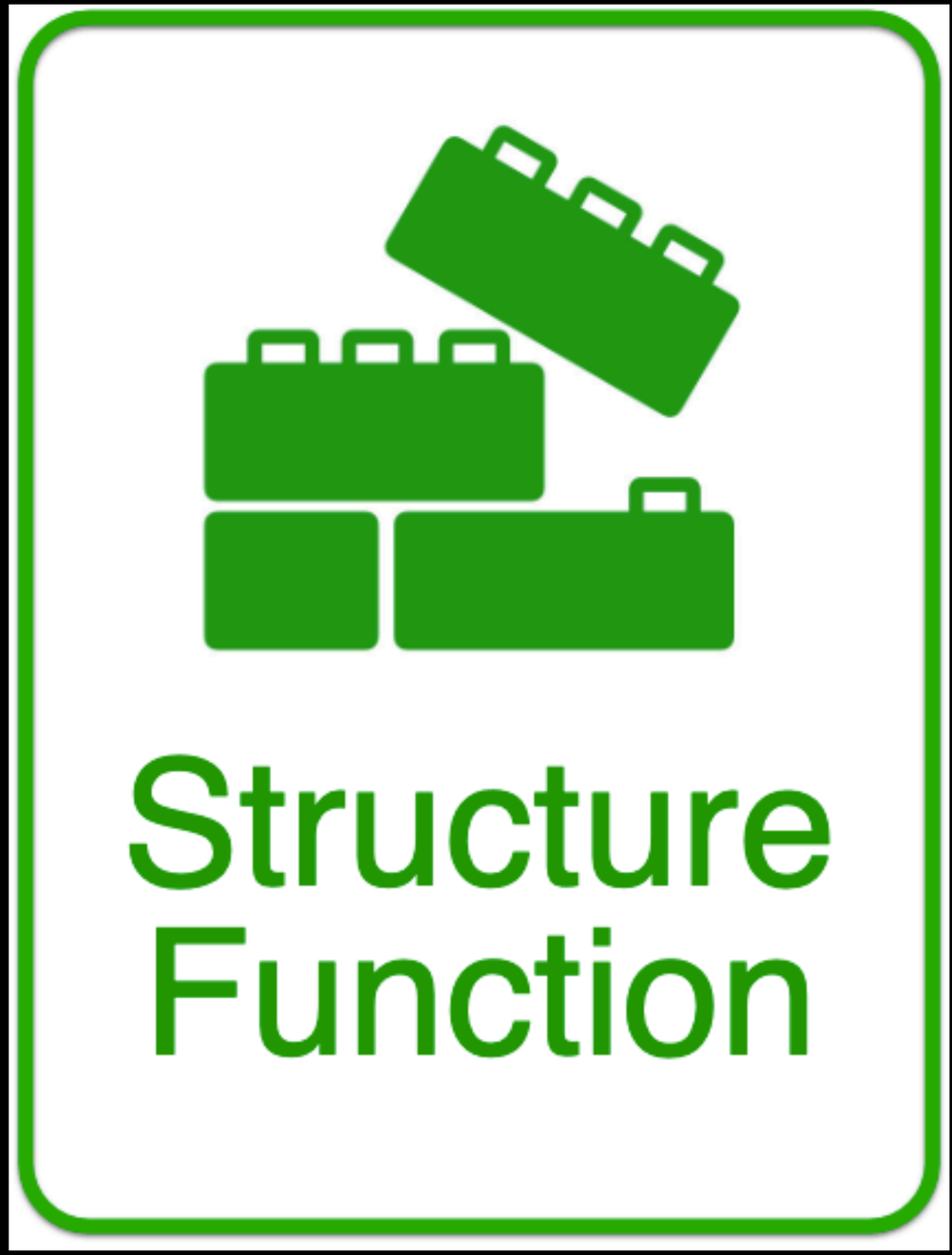

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STRUCTURE

What does it look like?

What is it made of?

FUNCTION

What does it do?

What is it's job?

STRUCTURE

What does it look like?

What is it made of?

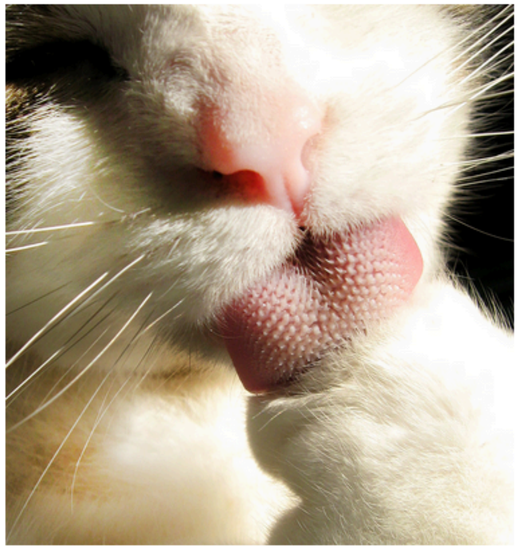
FUNCTION

What does it do?

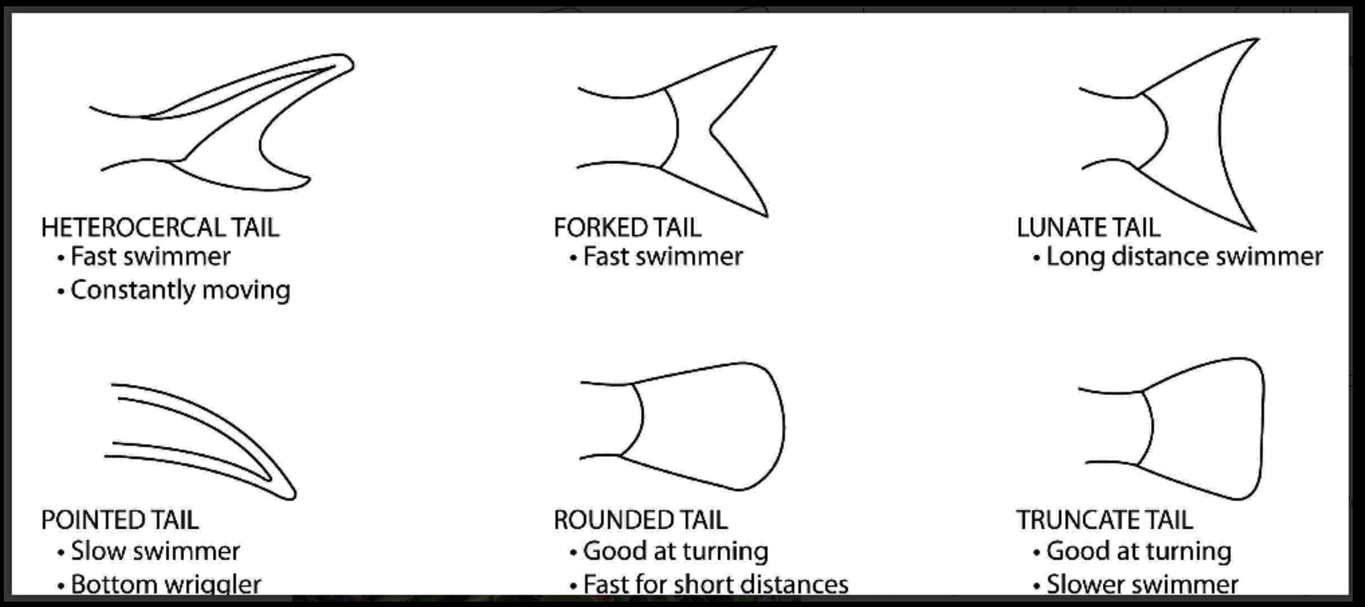
What is it's job?

https://youtu.be/AIvSxm7cWII?si=ESW1VdgxbxBBPyj8

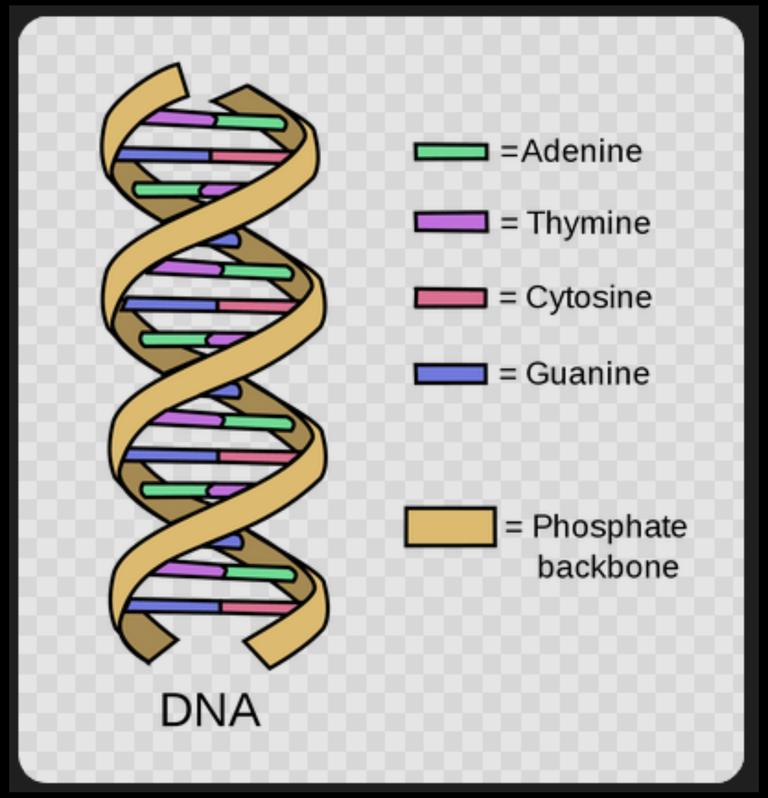
Cat's tongue



A cat's tongue has small barbs, called papillae, that make it easier for the feline to remove meat from the bones and tissues of the small prey they capture. The tongue is also used for effective grooming, which is actually a survival skill. After a cat devours its prey, it grooms itself in order to remove any lingering evidence of the kill, so as not to attract larger predators to the scent. Whether a cat is cleaning prey or cleaning itself, the tongue is able to do most of the work due to its barbed form.



https://toolbox.biomimicry.org/core-concepts/natures-unifying-patterns/shape/



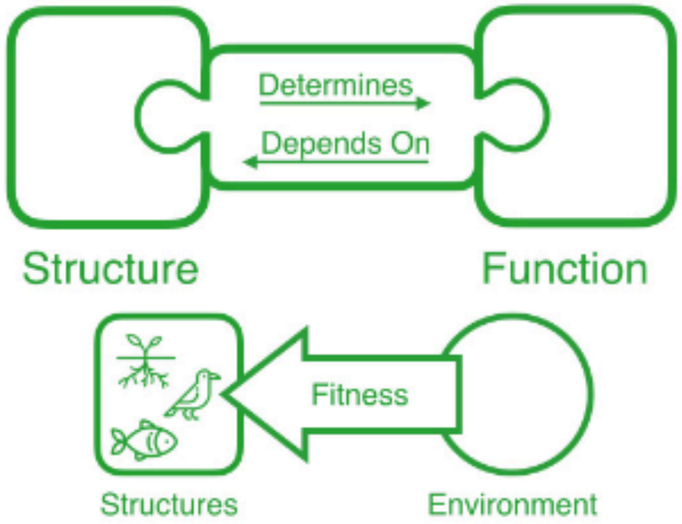
- ■ **Adenine (A)** always pairs with ■ **Thymine (T)**.
- ■ **Guanine (G)** always pairs with ■ **Cytosine (C)**.

Structure and Function

The way an object is shaped or structured determines many of its properties and functions.

Framing Questions

- What shapes or structures are observed in the system at this scale?
- What roles do these structures play in the functioning of the system?
- How do the structures support the functions?
- How does the environment affect the fitness of organisms with specific structures?



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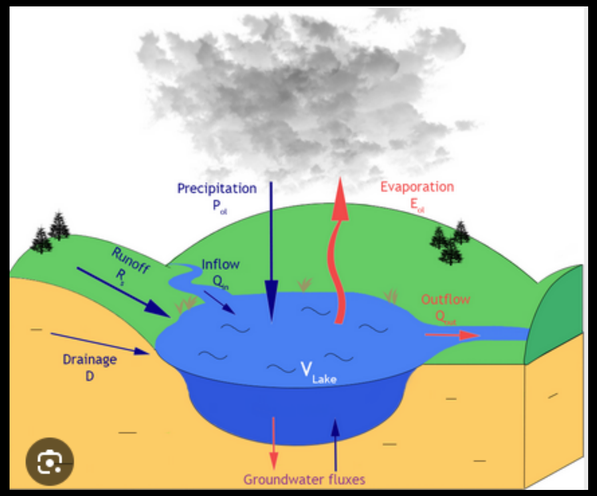
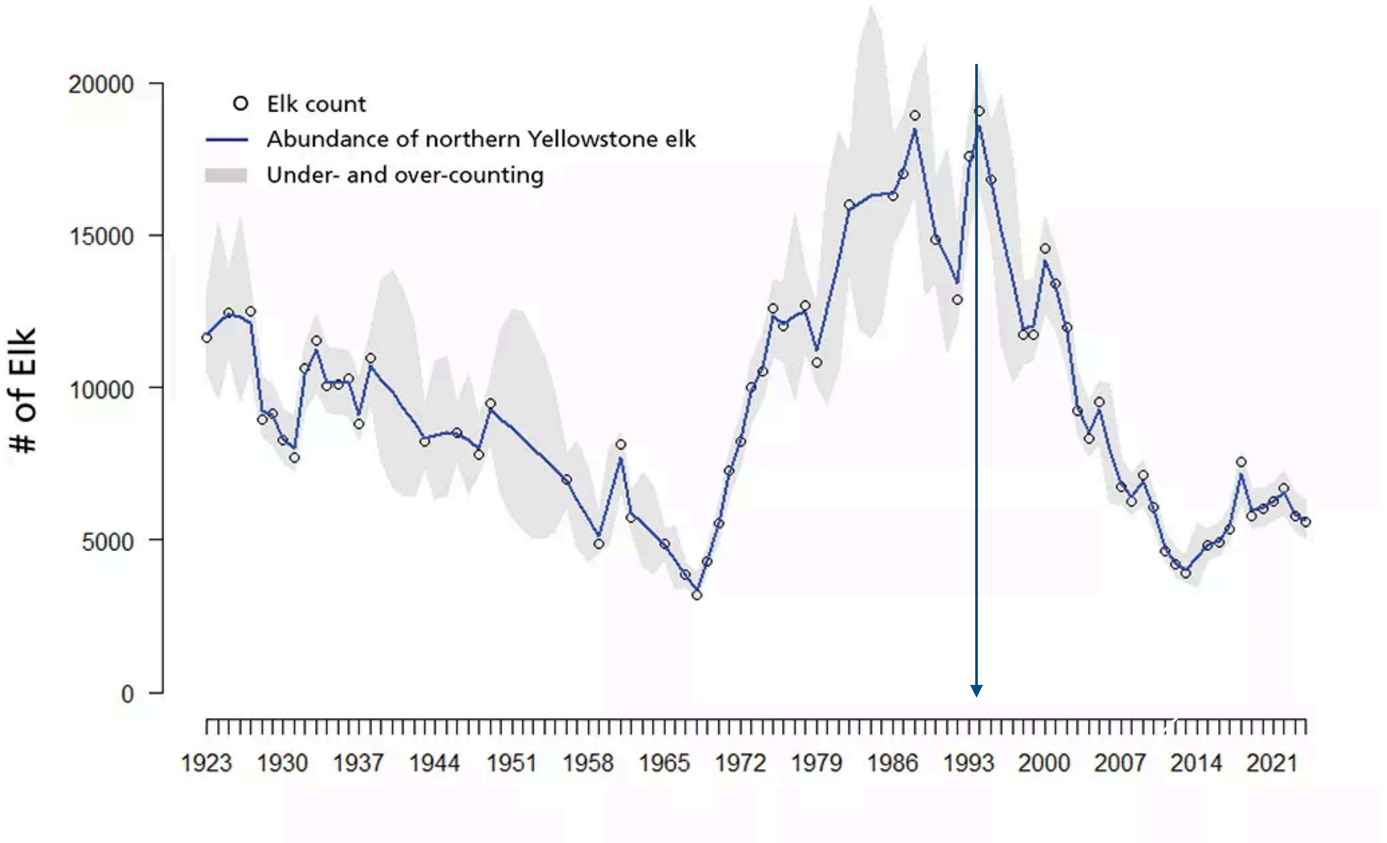
REGENT



https://gmd.copernicus.org/articles/14/1309/2021/

https://outsidebozeman.com/trails-tours/hiking-trails/hyalite-creek-trail



Abundance of the northern Yellowstone elk population, 1923–2024. Shaded area indicates uncertainty about the trend with respect to random under- and overcounting. These results underestimate the true population size because they do not account for imperfect sightability.

Data from the Northern Yellowstone Cooperative Wildlife Working Group

Stability and Change

Conditions that affect stability and factors that control rates of change are critical elements to consider and understand in natural systems.

Framing Questions

- Under what range of conditions does the system operate effectively?
- What changes in conditions cause changes in its stable operation?
- What changes in conditions could cause the system to become unstable or fail?
- What feedback loops in the operation of the system enhance its range of stable operations?

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Thank you

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