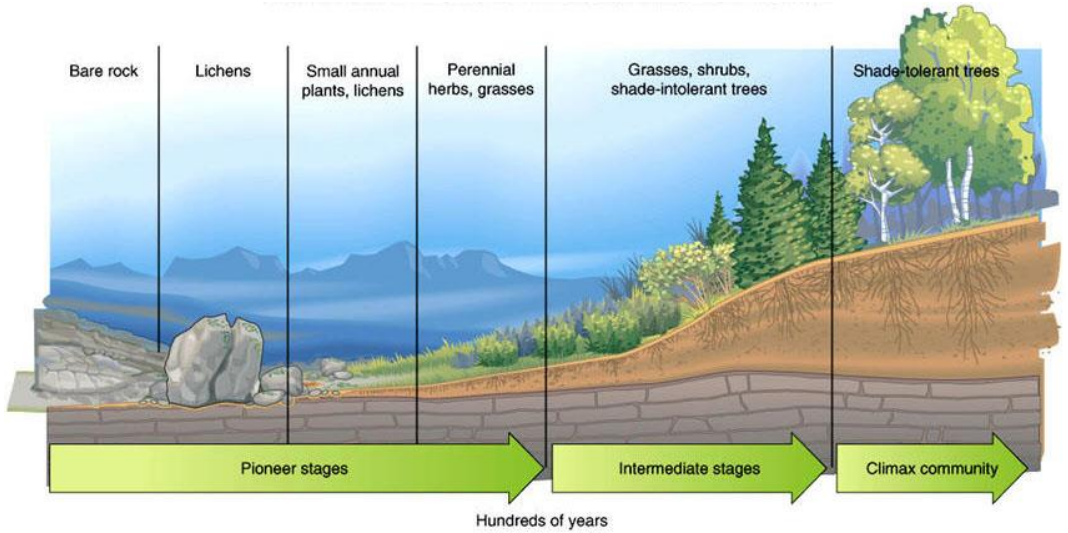
Today's class

Finish Community Ecology:

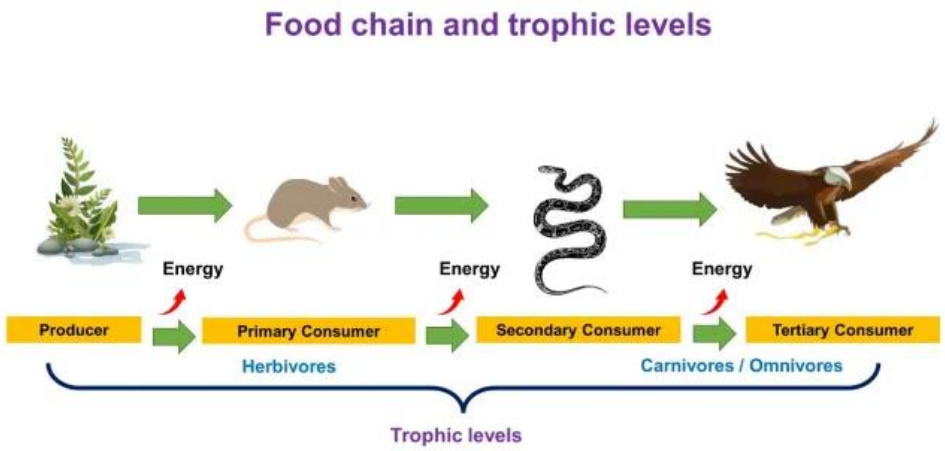
- Ecology Succession
  - primary
  - secondary



https://visityellowstonenationalparkyall.weebly.com/succession.html

Start Ecosystem Ecology:

- Energy Flow – Trophic Levels, food chains, food webs
- Nutrient Cycling



Science A plus

iClicker Question

Which of the following factors will be <u>first</u> to determine whether or not a species is found at a particular location?

A. Its fundamental niche
B. Its realized niche
C. Its ability to disperse
D. Its ability to outcompete other species

Answer

Which of the following factors will be <u>first</u> to determine whether or not a species is found at a particular location?

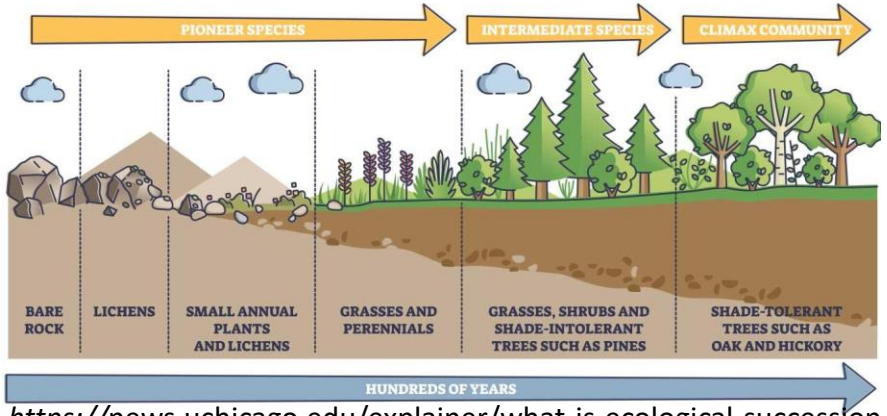
A. Its fundamental niche
B. Its realized niche
C. Its ability to disperse
D. Its ability to outcompete other species

Ecological Succession

https://news.uchicago.edu/explainer/what-is-ecological-succession

Ecological succession

- **Succession**: is a process in which the mix of species in an area changes over time (years to centuries).
- Typically refers to plant communities
- In ecological succession, one plant community gradually replaces (or succeeds one another) over time (predictable).
- Early plant communities create conditions that allow later plant communities to survive (e.g. adding nutrients to the soil).
- Succession stops (temporarily) when a climax community is reached.
- The climax community will exist until a **disturbance** occurs (which restarts the succession process)



*https://*news.uchicago.edu/explainer/what-is-ecological-succession

Disturbance

A disturbance refers to an event that disrupts the structure of a community.

Disturbances can take many forms and vary in intensity and size.

https://stanleyparkecology.ca/2016/11/01/wake-windstorm-new-way-forward-spes-stanley-park/

https://blogs.oregonstate.edu/treetopics/2014/01/09/chasing-early-seral/)

https://thetyee.ca/Analysis/2021/11/08/Bad-Year-Glaciers-BC-About-To-Get-Worse/

Two types of succession

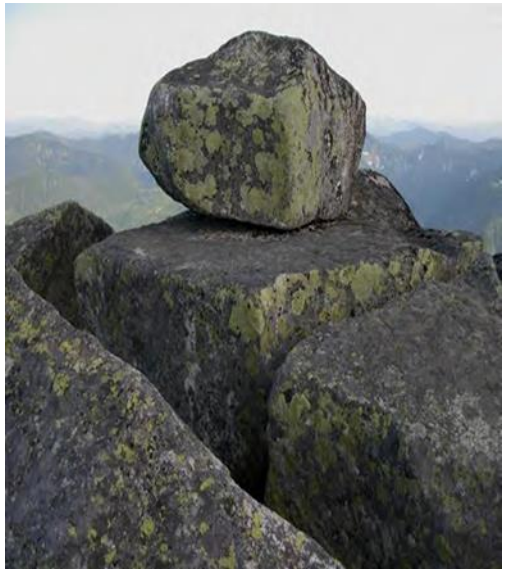
Primary succession: follows a disturbance that was sufficiently extreme to remove all the soil and all living organisms

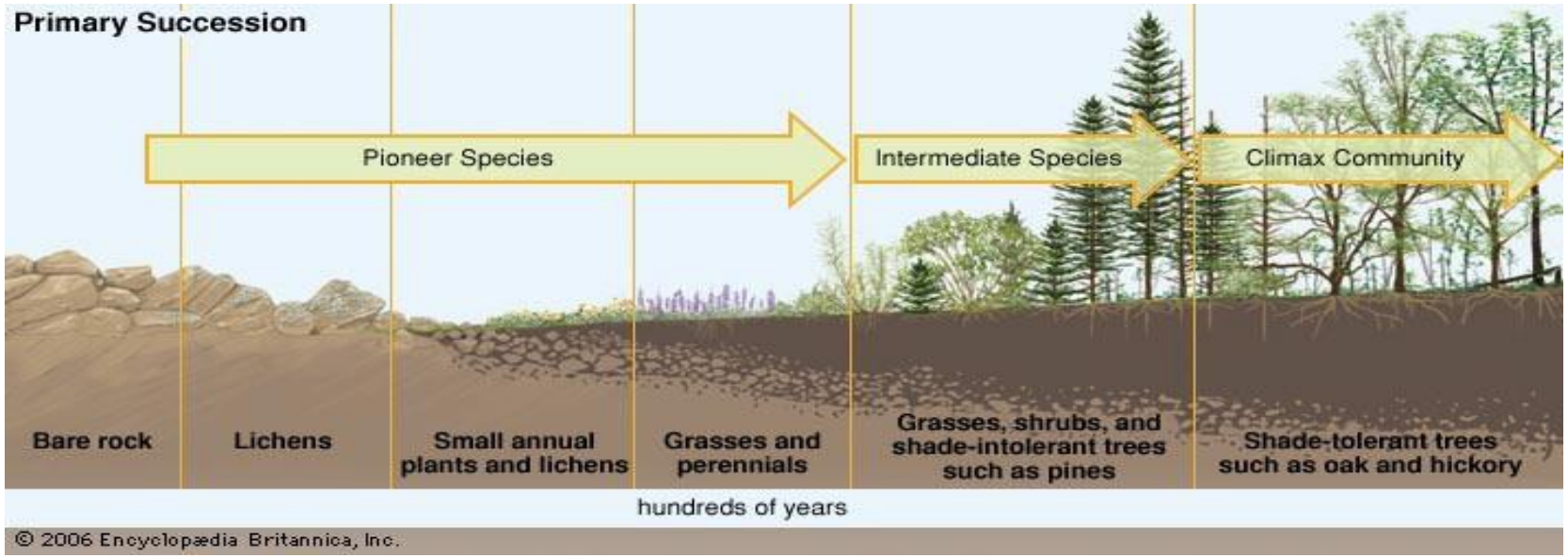
- Nothing remains after disturbance but bare rock/gravel.
- e.g. succession following:
  - Volcanic eruption
  - Glacier retreat
  - Extreme landslide leaving only bare rock
  - Surface mining

https://www.seattletimes.com/nation-world/mount-st-helens-which-erupted-41-years-ago-starts-reopening-after-covid-closures/
(https://blogs.oregonstate.edu/treetopics/2014/01/09/chasing-early-seral/)

Primary succession

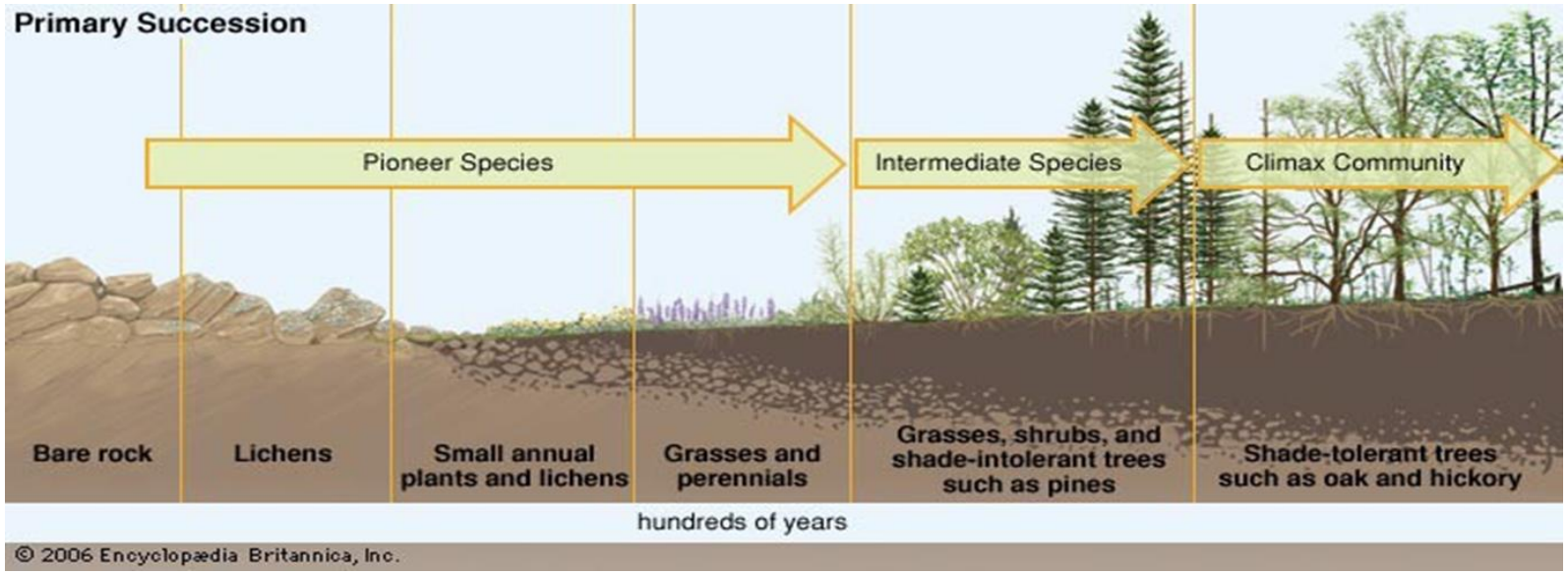
- Organisms need to start from scratch.
- Lichen might attach themselves to rock (see figure below)
- When they die, their remains will slowly contribute to the formation of soil
- A few small plants that do not require much soil (e.g. mosses) might then appear
- These early colonizers are called **PIONEERING SPECIES**.





Primary succession continued

- The decomposition of the pioneering species contributes to more soil formation.
- As the soil deepens, larger plants (with roots) can colonize the site.
- Larger plants provide cover and shade, which will restrict the growth of shade intolerant plants.
- Eventually a climax community is reached, unless a disturbance occurs to stop succession.



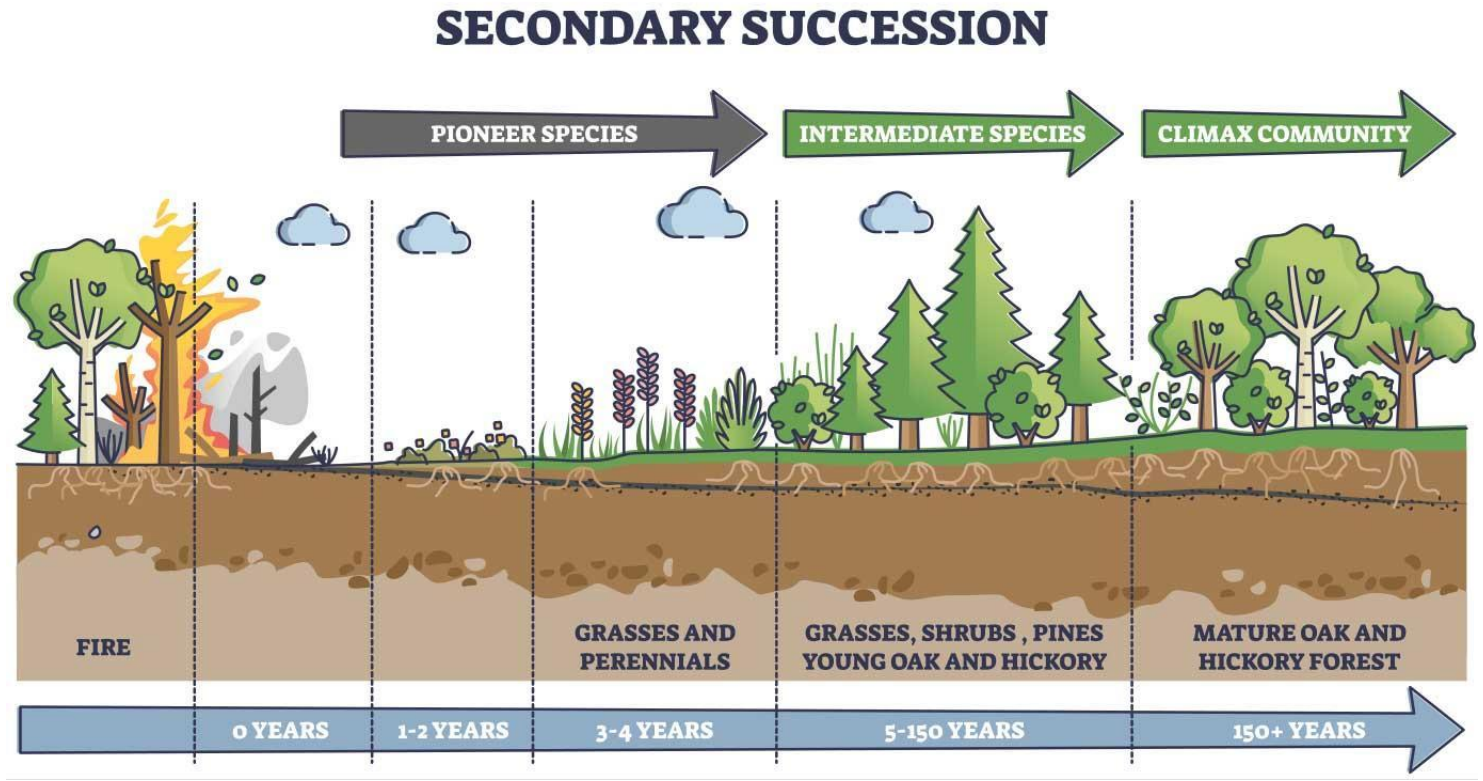
Secondary succession

Secondary succession: follows a disturbance that has removed some or all living organisms, but <u>soil</u> and nutrients <u>remain</u>

- e.g. succession following:
  - Forest fires
  - Logging
  - Construction
  - Farming
  - Moderate landslide
  - Flooding
  - Windstorms
  - May be biotic (e.g. mountain pine beetle)

Secondary Succession

An example of secondary succession would be succession following a forest fire. After the fire, grasses and other pioneering species will grow, followed by shrubs (intermediate species) and a variety of tree species, until a climax community is reached.



Note – in coastal B.C., climax forests are dominated by western hemlock, western red cedar and Douglas fir. (note testable) – this image is for an eastern forest.

https://news.uchicago.edu/explainer/what-is-ecological-succession

Example of secondary succession: cultural burning

https://prescribedfire.ca/cultural-burning/

I have posted a link on our Canvas page > Ecology Additional Materials about the very important role of Cultural Burning in maintaining biodiversity in B.C. and beyond.

Ecology Cultural Burning is a contemporary term to describe a traditional practice that has existed since time immemorial.

Practiced by Indigenous people around the world.

It is defined as the controlled application of fire on the landscape to achieve specific cultural objectives.

These burns are typically implemented at low intensity, with guidance from an Elder or Fire Knowledge Keeper.

“Common objectives for cultural burning include but are not limited to cultural and language preservation, fuel mitigation, food and medicinal plant revitalization, and habitat enhancement.”

Banned in B.C. in 1874 with negative ecological and cultural repercussions.

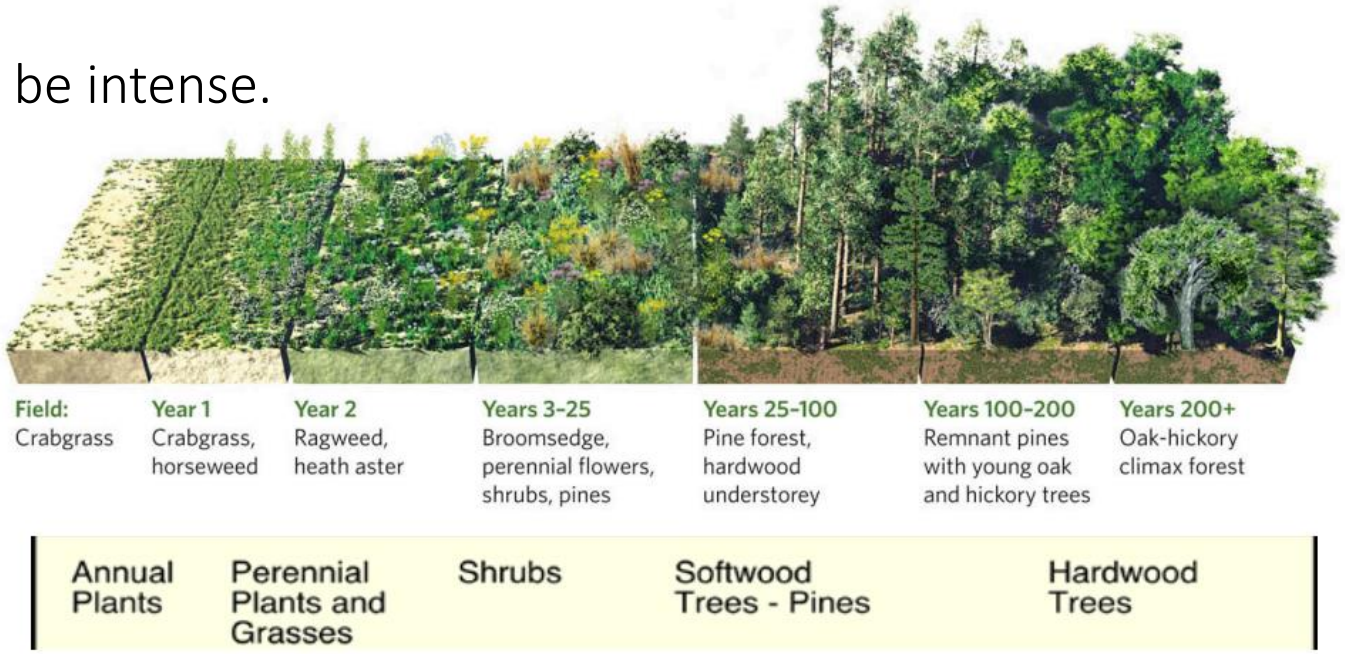
In both types of succession

In early succession:

- Abiotic condition in early succession can be harsh (e.g. no protection from wind, direct sunlight, extremes of temperature, nutrients may or may not be present).
- But competition is low because relatively few species present.

In later succession:

- Abiotic conditions are less harsh.
- But competition for limited resources can be intense.



Factors that can influence the pattern of succession

1. Species (life history) traits*
2. Interactions amongst species
3. Historical and environmental circumstances

* You only need to know species traits for the final exam

Question – discuss – 1 minute

Which traits would you expect to be associated with species occurring in early (pioneer) successional stages?

Early reproductive age

Devotes most of energy to growth

Long life span

Numerous small seeds

r-selected life history traits

K-selected life history traits

Strong competitor

Can tolerate severe abiotic conditions

Answer

Which traits would you expect to be associated with species occurring in early (pioneer) successional stages (i.e. when abiotic conditions can be hostile to life)?

Early reproductive age

r-selected life history traits

Devotes most of energy to growth

K-selected life history traits

Long life span

Strong competitor

Numerous small seeds

Can tolerate severe abiotic conditions

Prairie or Pacific Lupine (*Lupinus lepidus*)

This was the first plant (or one of the first plants) to recolonize Mt. St. Helens after it erupted.

Listed as an endangered species in Canada

- Found in B.C. (southern Vancouver Island) through Washington and Oregon
- Habitat destruction/degradation from development

Biology:

- Relatively short lived: max. age of 5 years
- Starts reproducing in 2nd year
- Small plant (maximum size of 10-60 cm tall)
- Weak competitor that requires few competitors or constant disturbance to remove competitors
- Prefers stressful sites with low moisture content.
- Flowers have male and female reproductive parts (so can self fertilize)

https://sararegistry.gc.ca/virtual_sara/files/cosewic/sr_prairie_lupine_0809_e.pdf

https://en.wikipedia.org/wiki/Lupinus_lepidus

Plant traits associated with successional stages

Trait	Early successional species (*r*-selected)	Late successional species (K-selected)
Seed number	Many (low quality)	Relatively few (higher quality, i.e., more energy stores)
Seed size	Small	Larger
Seed Dispersal Distance	Far	Shorter distances
Seed Dispersal Mechanism	Wind and animals (e.g., birds, bats)	Animals (e.g.mammals such as squirrels), gravity
Size at maturity	Small	Large
Structure strength	Low (no woody tissue) - exceptions	High
Population growth rate	Rapid (*r*)	Slow (*r*)
Maximum life span	Short (e.g., 1 year) – exceptions; most offspring die before reaching reproductive age	Longer (>100 years); most offspring survive to reproductive age
Shade tolerance	Low	High
Tolerance for low nutrient availability (e.g. N)	High	Low
Competitive ability	Low (relatively) – *r*-selected	High – K-selected

Optional Ecology Worksheets (Canvas)

Brett's Alaskan Forest Worksheet

Alaska Forests Worksheet
BIOL121 2022

Alaskan Forests

Rees and Juday (2002) examined the effects of natural fires and logging by humans on the number of plant species present at different times following disturbance. Multiple sites were chosen that represented different times following burning or logging. The results are shown in the figure.

1) Fire and logging are examples of _____

2) The development of communities after events such as fire or logging is called:

_____

3) Describe the results shown in the figure (pattern, numerical values, whether significant difference or not, if p-value or * provided).

Other factors that influence pattern of succession – not testable

a) FACILITATION

Presence of one species facilitates the establishment or growth or another species.

- e.g. red alder has symbiotic relationship with a nitrogen-fixed bacteria, *Frankia* sp., that allow red alder to colonize nutrient-poor sites.
- when the leaves of red alder fall in the autumn, detritivores breakdown leaves adding N to soil.

http://nativeplantspnw.com/red-alder-alnus-rubra/

Species Interactions – not testable

b) INHIBITION

- Presence of one species inhibits the establishment or growth or another species.
- For example, Douglas fir trees will intercept light, preventing other plant species that require high levels from germinating, except in locations where the forest canopy is open (e.g. Salmonberry, *Rubus spectabilis*).

http://nativeplantspnw.com/red-alder-alnus-rubra/

- Some plants release toxic compounds that negatively impact seedling growth, root development or nutrient uptake (allelopathy)

https://www.thespruce.com/growing-sunflowers-1402916

Chance, History & Environment – not testable

8:32 am on May 18, 1980, Mt. St. Helen's in Washington State erupted.

Timing: Day & Season helped some organisms to survive.

Early morning – some animals (e.g. nocturnal) still in burrows (mice, voles)

There was still snow on the mountain. Many amphibians were still in hibernation. Lakes were still frozen (providing some protection to trout and amphibians, e.g. salamanders).

Saplings (e.g. Mountain Hemlock) and other plants buried in the late winter snowpack or under blown down trees survived.

https://www.mshslc.org/return-to-life/facts-and-research/faqs-on-return-to-life/why-did-so-many-plants-and-animals-survive-the-eruption/

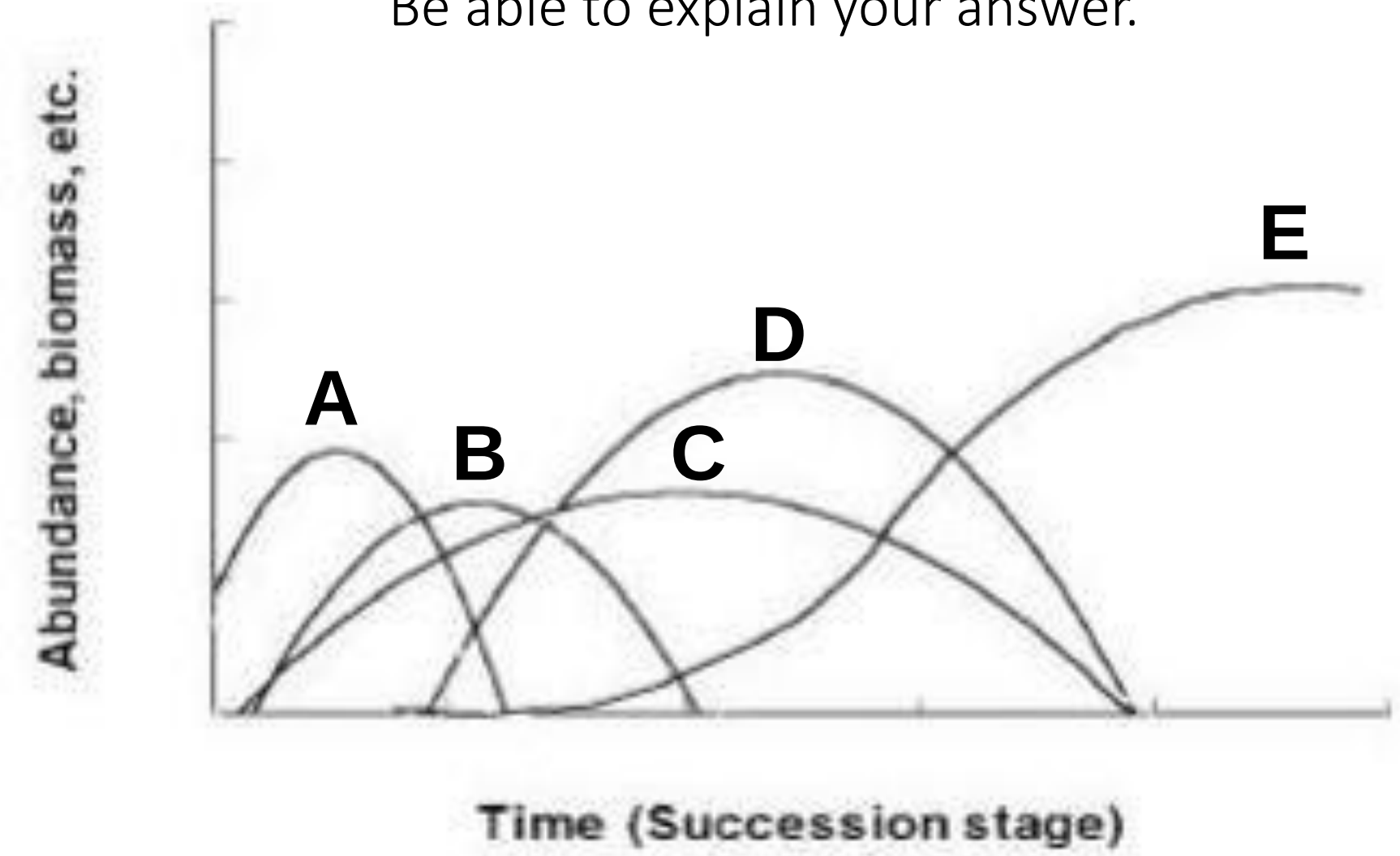
https://www.popsci.com/story/science/mount-st-helens-eruption-book/

https://www.livescience.com/6450-mount-st-helens-recovering-30-years.html

iClicker Question = 1 minute – discuss with neighbours

True or false - Plant E can probably tolerate low light intensities?

Be able to explain your answer.



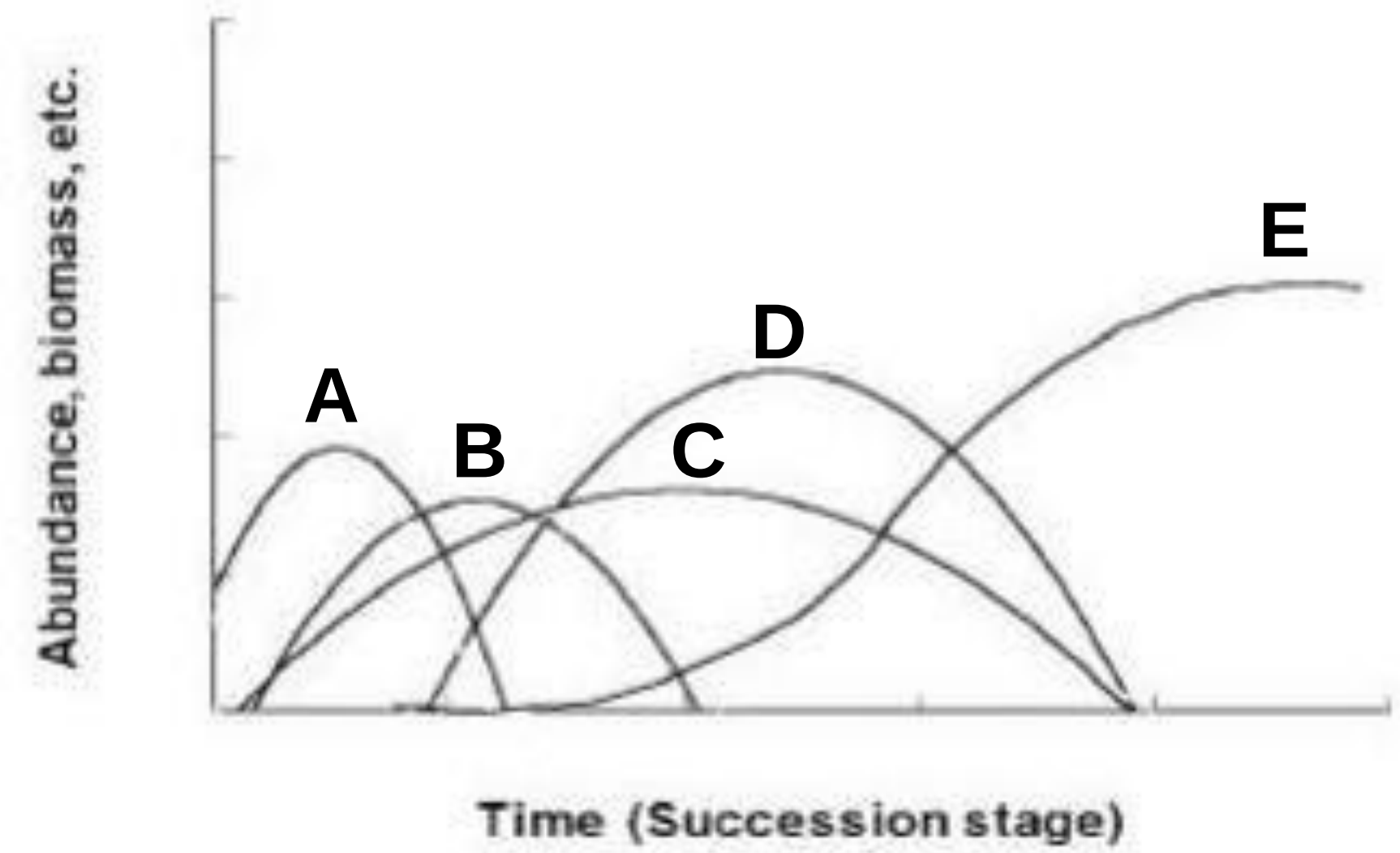
A. True

B. False

C. I am not sure

Answer

True or false - Plant E can probably tolerate low light intensities?



A. True

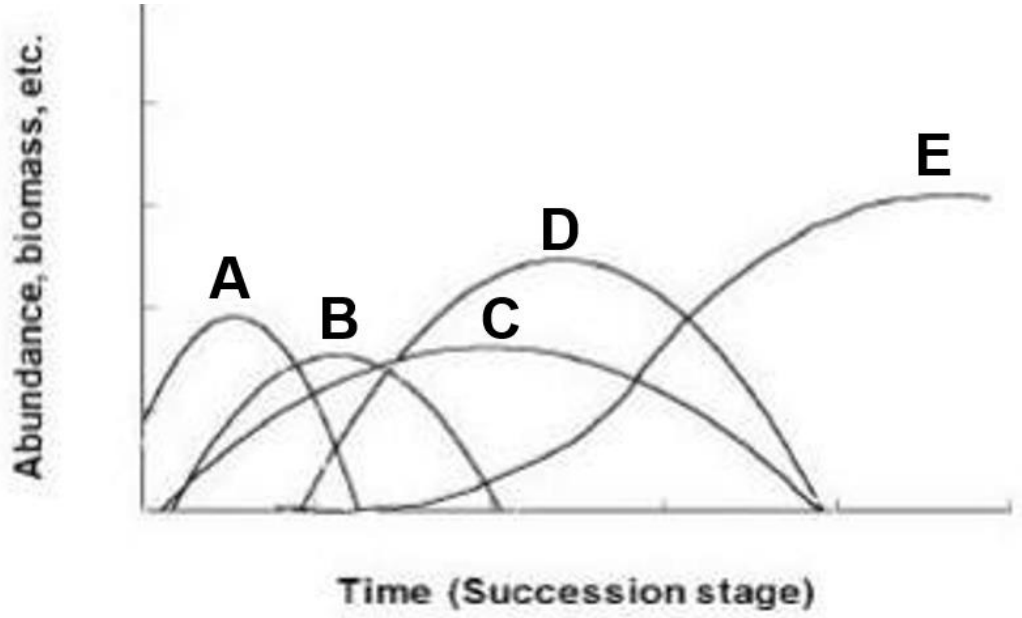
B. False

C. I am not sure

Example answer:
Yes, plant “E” can tolerate low light intensities (Claim).

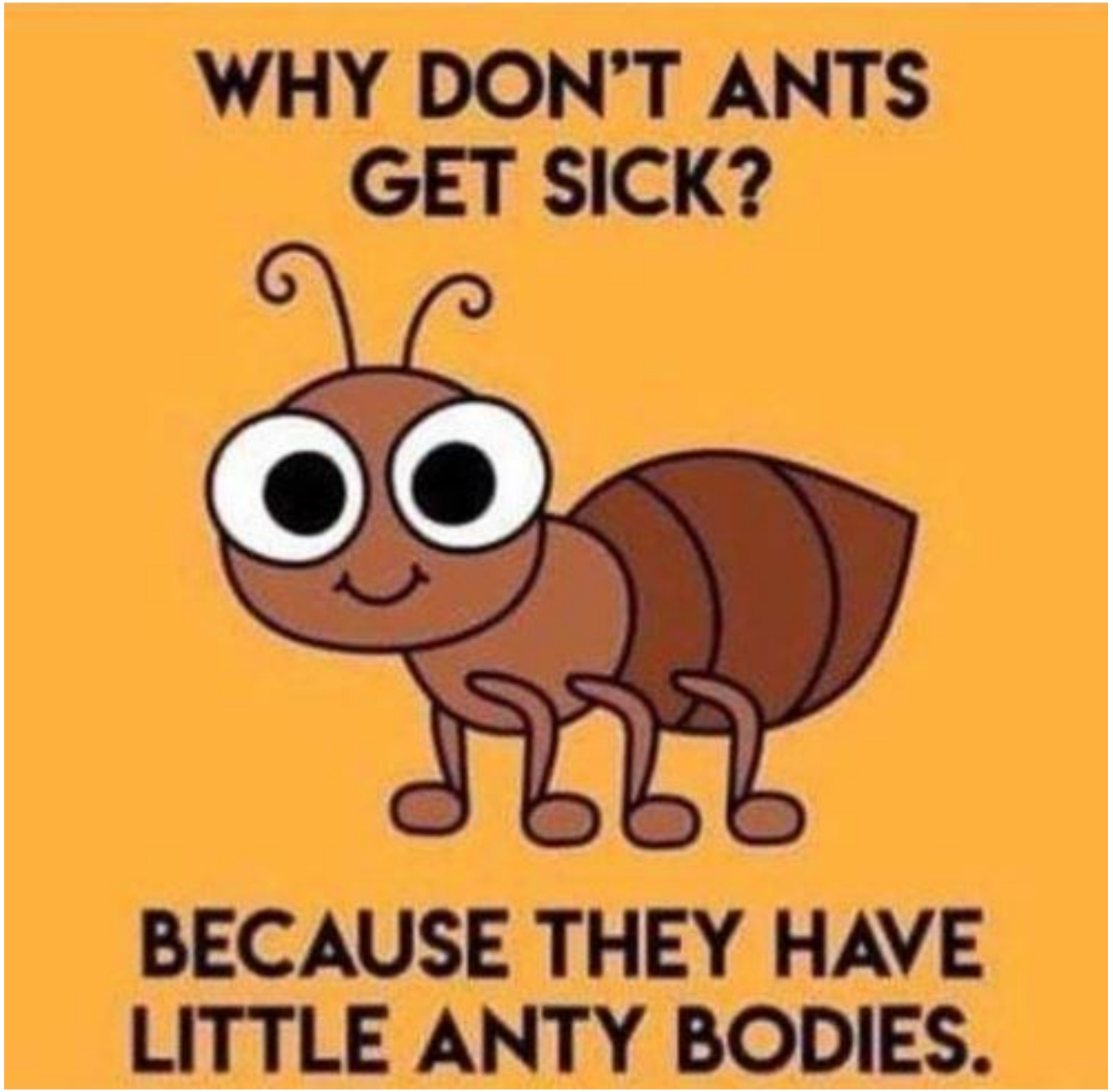
Plant “E” germinated and grew when other plant were present (plant “B”, plant “C”, and plant “D”). These plant which would have at least partially shaded the ground/soil on which plant “E” was growing. (reasoning)

Therefore, plant “E” was able to survive and grow in less than full light intensity suggesting that they are tolerant of low light intensities. (reasoning – bringing it back to the claim).



Learning goals - succession

- Predict how changes in abiotic or biotic factors or disturbances can affect patterns of succession and community composition over various time scales.
- Describe general characteristics of types of species found at different successional stages in a forest biome (e.g., dispersal ability, competitive ability).
- Given a scenario, identify the successional stage of a community.



5-minute break

What is an ecosystem?

Ecosystem: A **biotic community** and its **abiotic environment**

- may be small (e.g. puddle) or large (e.g. Great Bear rainforest)

- may be terrestrial (land-based), aquatic (marine or freshwater), or both

Ecosystem ecologists ask:

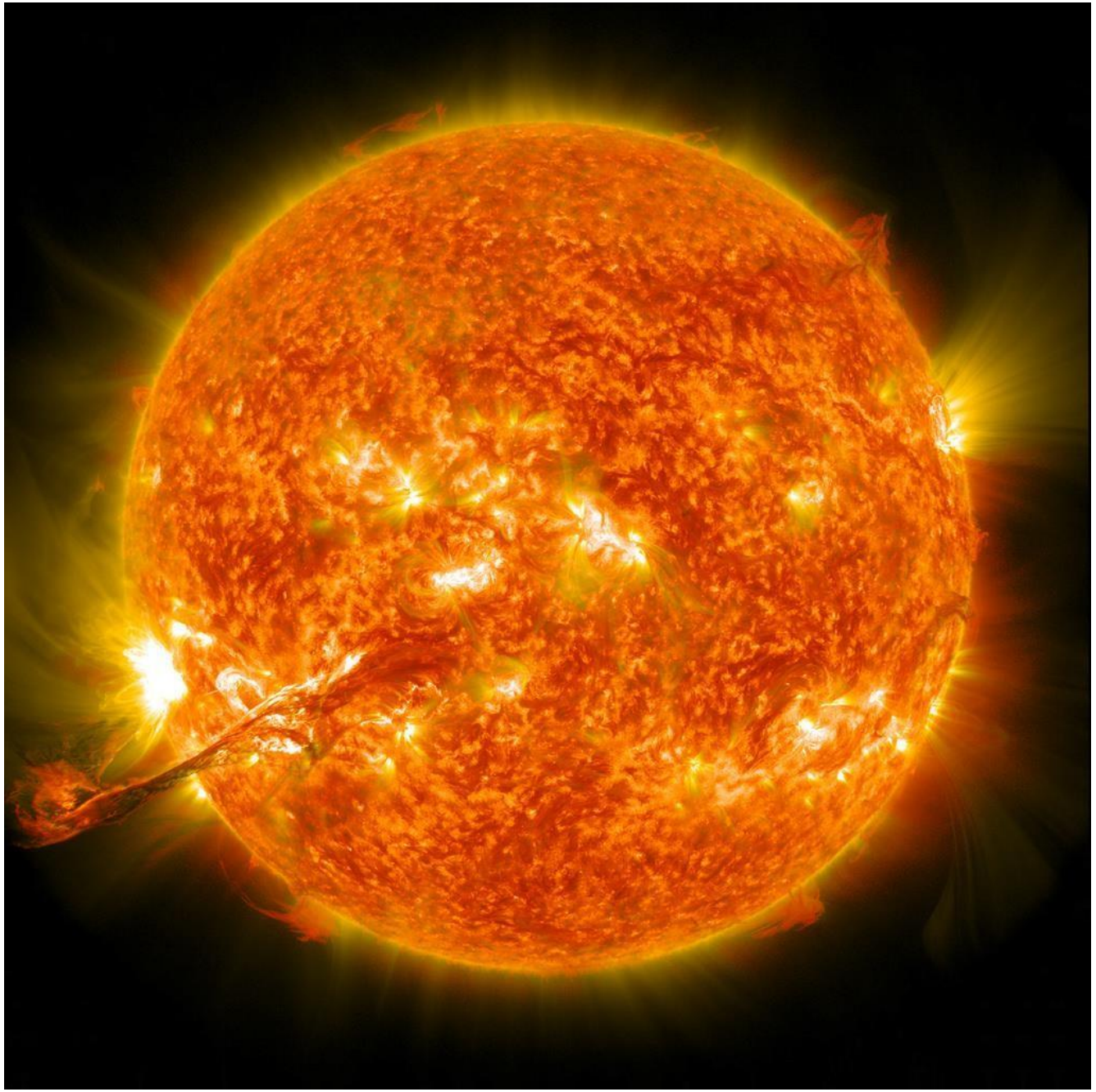
- How does energy flow through a system?

- How do nutrients cycle between the abiotic and biotic components of a system?

Energy Flow

- All organisms require energy to survive, grow, repair, reproduce, and in many species, move.

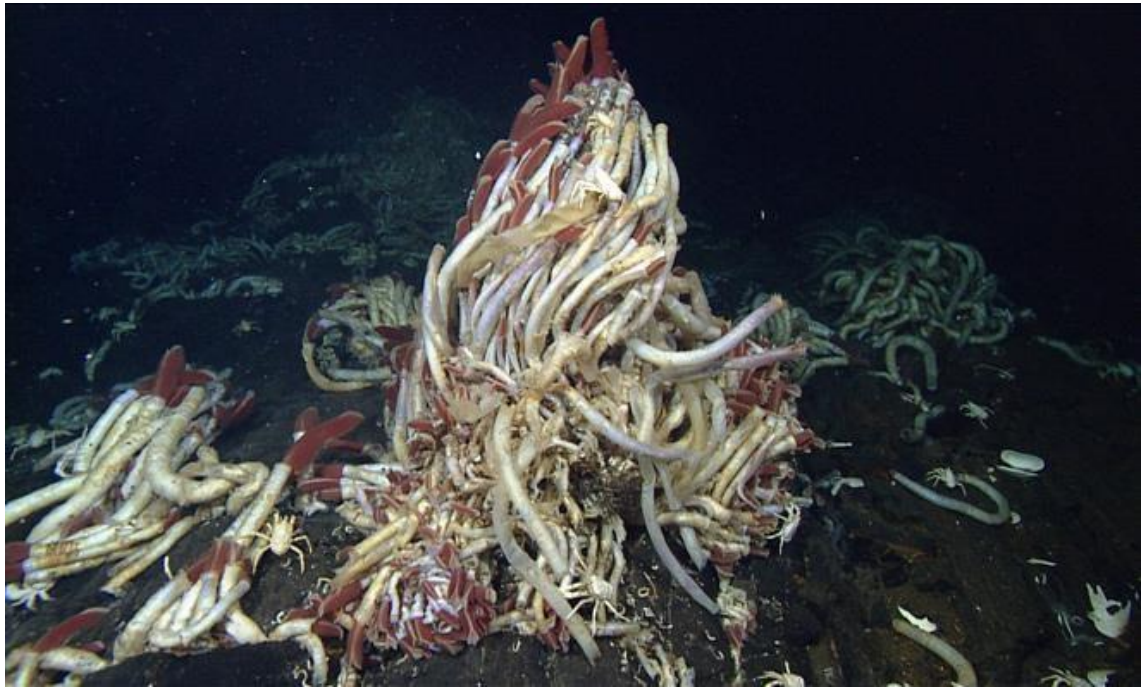
- The ultimate source of this energy for most of life is……



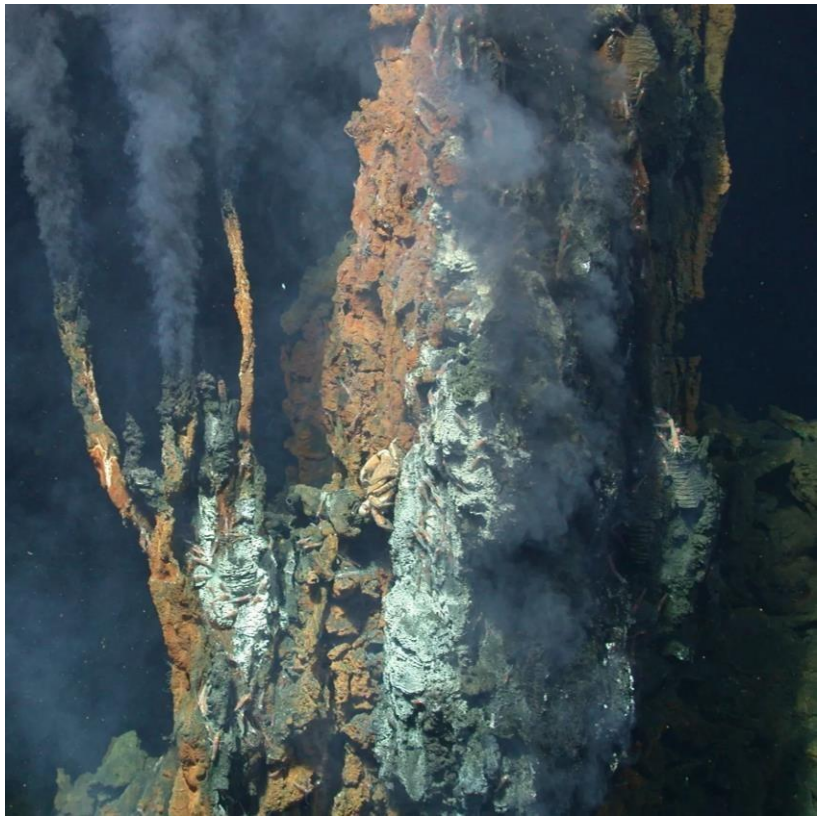
*Exceptions – not testable

There are a few amazing exceptions, e.g. hydrothermal vent communities, which are found a mile or more below the ocean's surface.

- powered by chemosynthesis



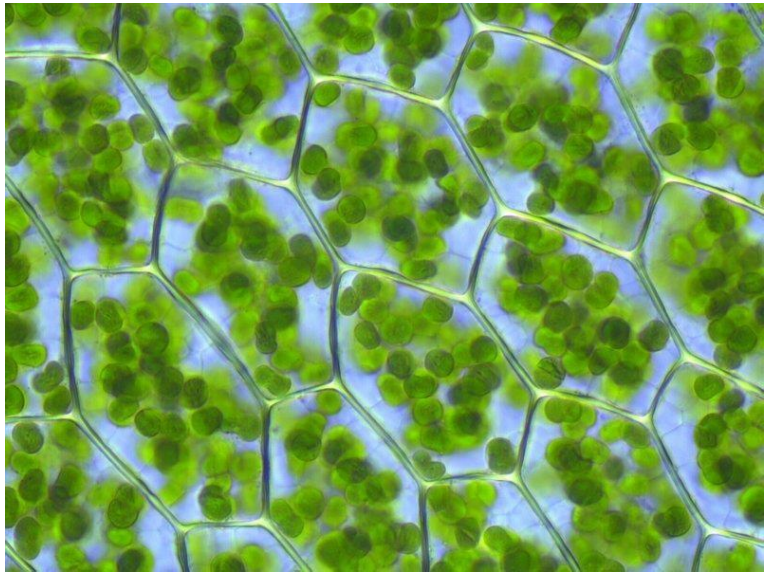
https://www.wired.com/2012/05/how-to-discover-deep-sea-hydrothermal-vents/



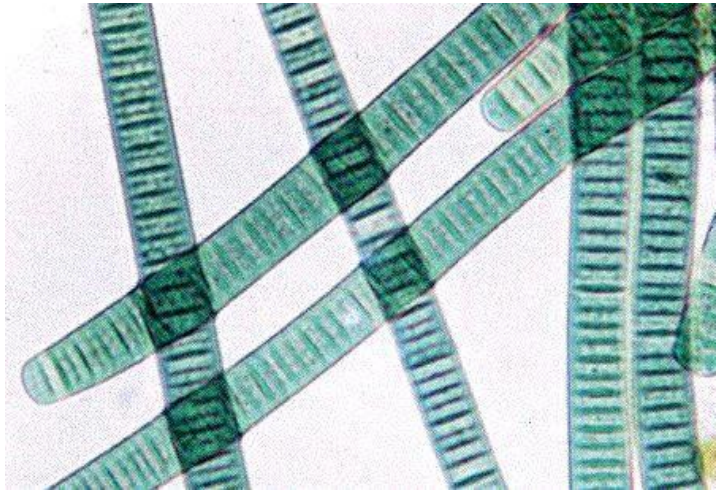
https://www.popsci.com/qa-extremophile-hunter-whos-grown-some- worlds-weirdest-microbes

Producers

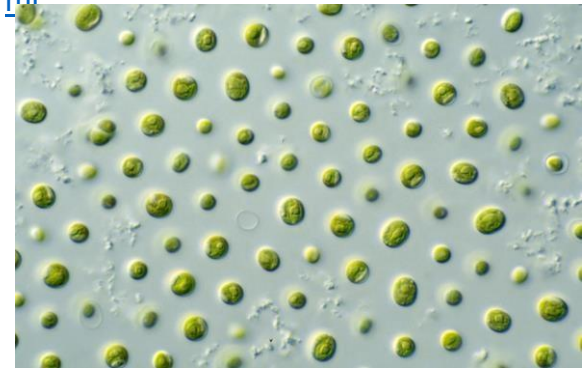
Producers (a/k/a autotrophs) obtain their energy by use photosynthesis to convert solar energy to chemical energy.



By Kristian Peters -- Fabelfroh - Self-photographed, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1350193



http://www.ucmp.berkeley.edu/bacteria/cyanointro.html



Consumers

Consumers (a.k.a. heterotrophs):
obtain energy by eating other organisms

Two types of consumers that eat dead organic material:

Detritivores: ingest dead organic material, break down material internally (e.g. earthworms, slugs)

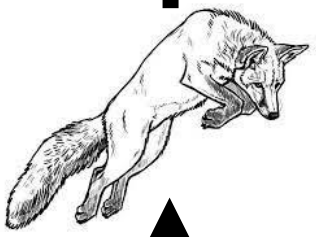
Decomposers: break down dead organic material, then absorb nutrients (e.g. Fungi and some bacteria)

Consumers

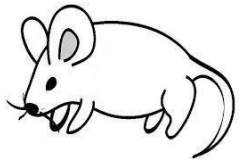
Trophic levels

Tertiary (3°) consumer

Secondary (2°) consumers



Primary (1°) consumers
(Herbivores)



Producers
(autotrophs)

Decomposer & Detritivore

Organisms are classified into trophic levels based on their source of energy

Energy Flow - Trophic Levels

Source of Energy	**Trophic Level**		Examples (terrestrial)
Sun (or chemicals)	Producer		Plants, algae, photosynthetic bacteria
Producers	Primary Consumer (1°)	Consumers that eat plants	mice, squirrels, grasshoppers, some tadpoles, some snails
Primary Consumer	Secondary Consumer (2°)	Consumers that eat herbivores	some snakes, northern spotted owl, coyotes, sea stars
Secondary Consumer	Tertiary Consumer (3°)	Consumers that eat carnivores	mink, raccoons, gulls
Tertiary Consumer	Quaternary Consumer (4°)		great horned owl, eagles, cougar

Dead Organic Material	Decomposers	External digestion	Fungi, bacteria
Dead Organic Material	Detritivores	Internal digestion	Earthworms, slugs, some beetles, some crabs

Food chain

Food chain: is a diagram that shows the linear flow of food energy from one trophic level to the next trophic level.

Note: direction of arrows is important

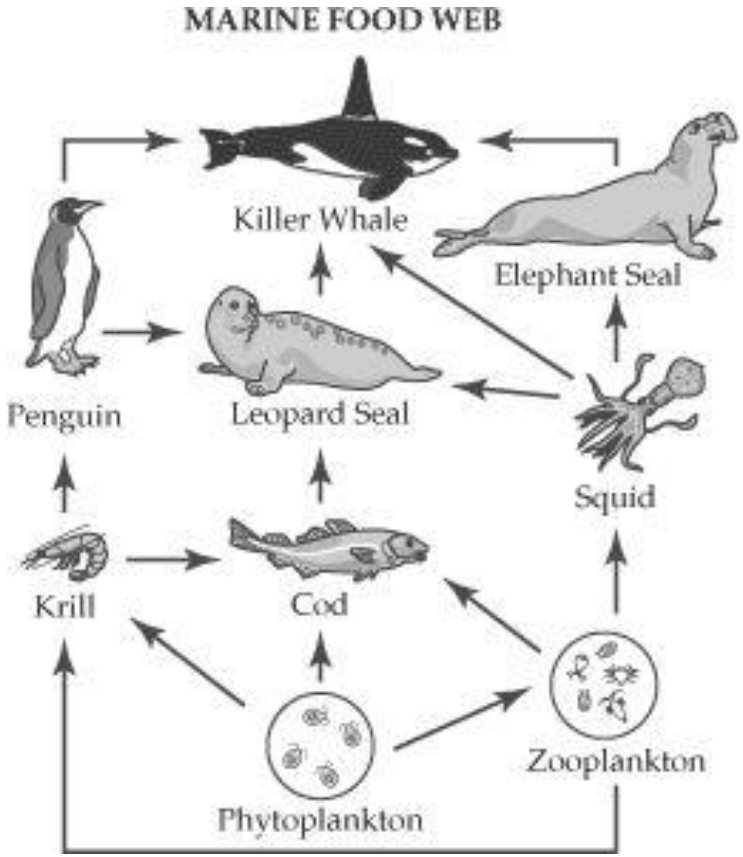
Producers ➡ Primary Consumers ➡ Secondary consumers ➡ Tertiary consumers

Wikipedia.org

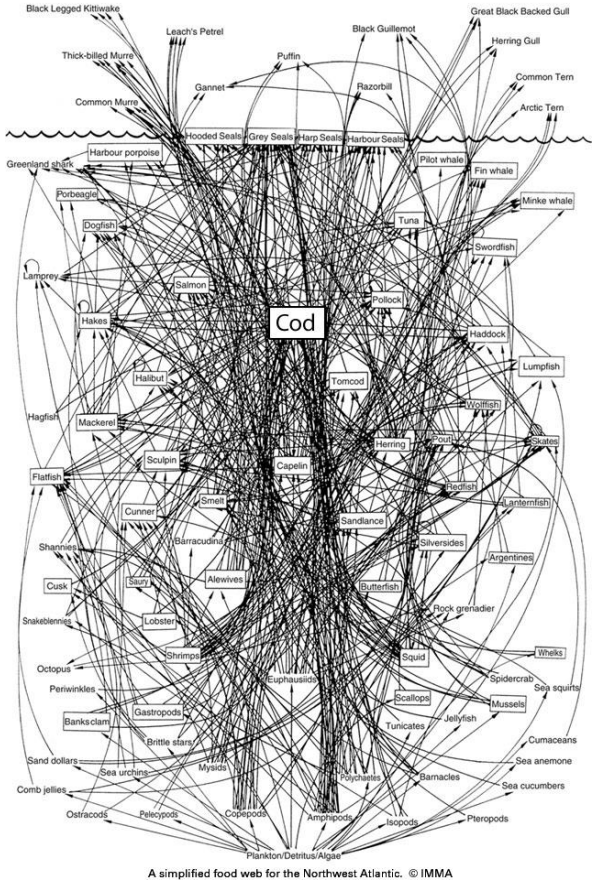
Food webs are more realistic than food chains

Food web: a series of interlocked food chains that allow for the possibility of omnivores (consumers of multiple trophic levels)

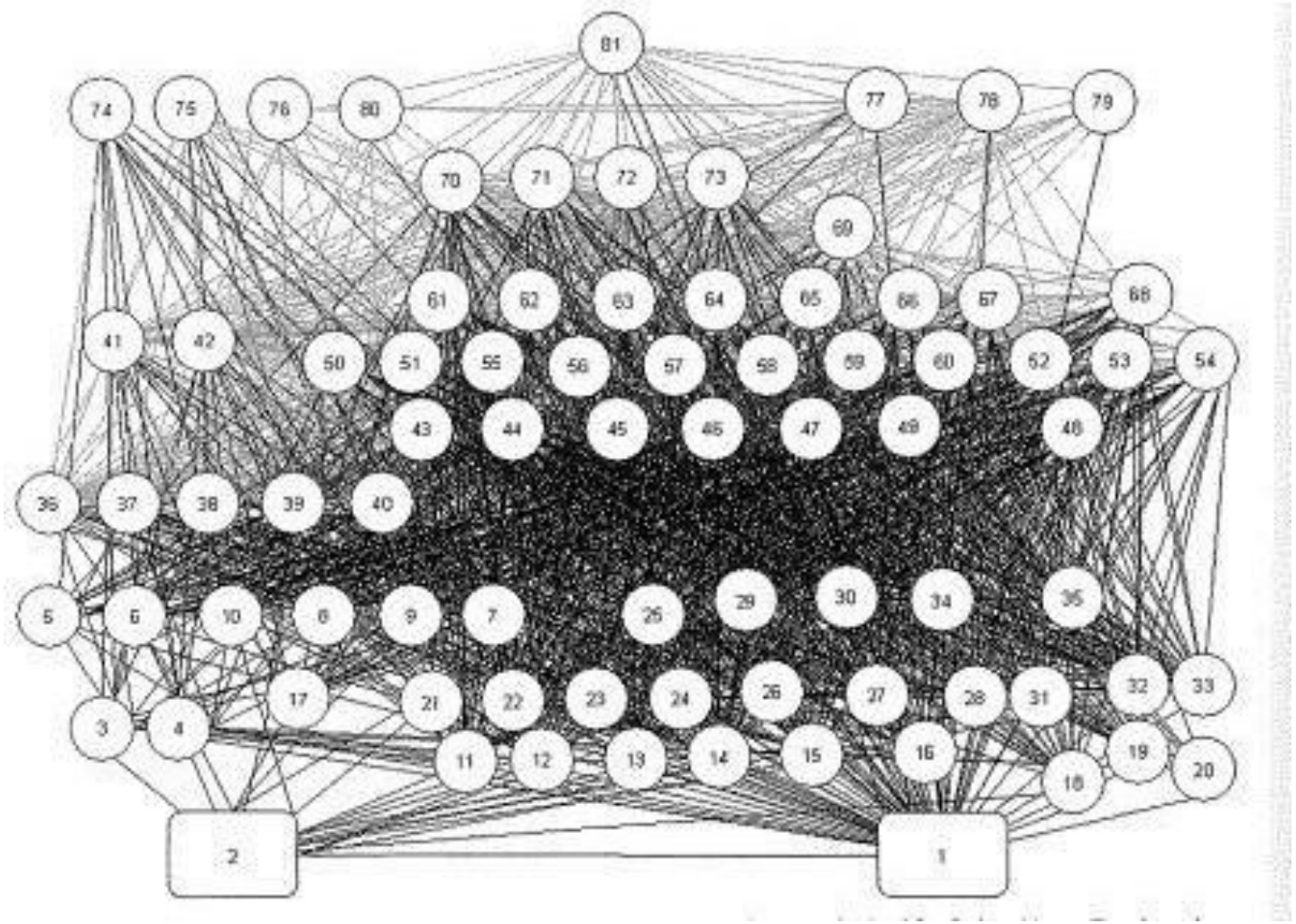
A simplified food web:



A realistic food web:



Coastal marine food web, Eastern Canada



Krebs
2016

4 of 5 learning goals for today – energy flow

- Given a scenario, be able to identify the trophic level of an organism
- Be able to describe the flow of energy through a food chain or food web and predict the consequences of changes to the system
- Be able to build a food chain or food web if given information about the organisms present in an ecosystem (e.g., taxa or biomass).

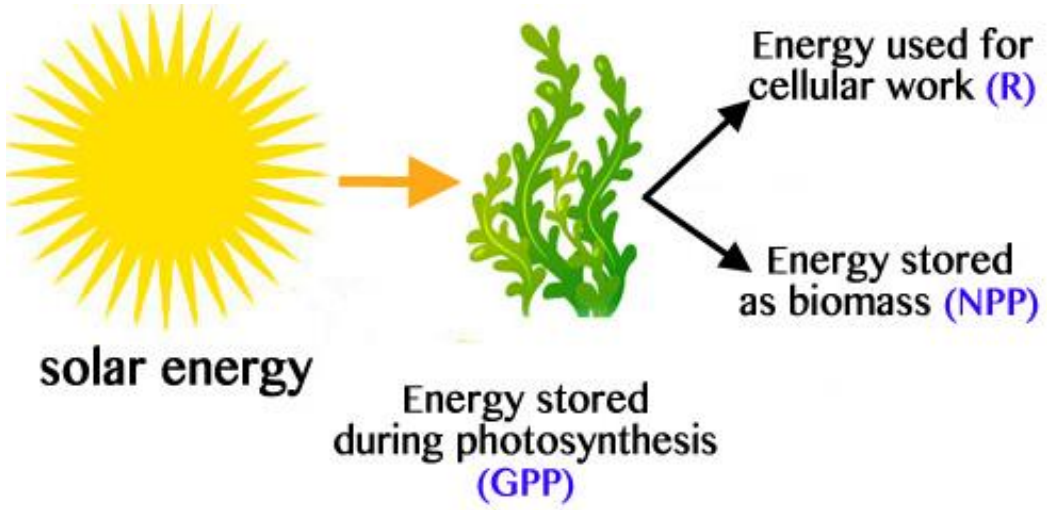
- Understand the concept of primary productivity (or primary production)

The amount of energy available to an ecosystem can be measured as **NPP**

Primary productivity: rate of conversion of solar energy to chemical energy (a.k.a. carbon capture) by producers. Expressed as biomass/area/time or energy/area/time

Gross primary productivity (GPP): absolute rate of primary productivity

Net primary productivity (NPP): rate of primary productivity after accounting for cellular respiration



$$NPP = GPP - R$$

net primary productivity = gross primary productivity − respiration

* Biomass = mass of living organisms

5th learning goals for today – energy flow

- Be able to explain why energy/biomass is lost between trophic levels.

Energy is lost between trophic levels - Testable

Ten percent rule:
Approximately* 10% of the chemical energy at one trophic level is **transferred to the next trophic level.**
*Availability of energy actually varies from 2-30%

Any thoughts as to the reasons why? Please discuss for one minute.

e.g. why fewer *Orca* than salmon?

https://www.researchgate.net/figure/Photograph-of-a-killer-whale-catching-an-Atlantic-salmon-Salmo-salar-in- northern-Norway_fig42_319527386

Why energy is **lost** between trophic levels

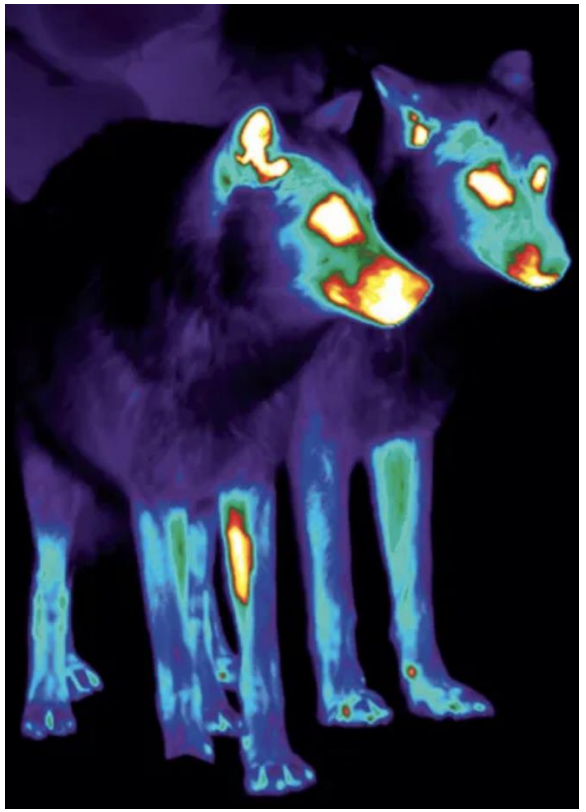
Energy is lost multiple ways. For example:

- Not all of the organisms at one trophic level are consumed by organisms at the next trophic level (e.g. ~90% of producer biomass is consumed by detritivores and decomposers).

- Not all food eaten is completely digested
  - e.g., plants contain indigestible fibre (why we need an opening at the end of our digestive tract ☺).

- Energy is lost as heat (by-product of metabolism).

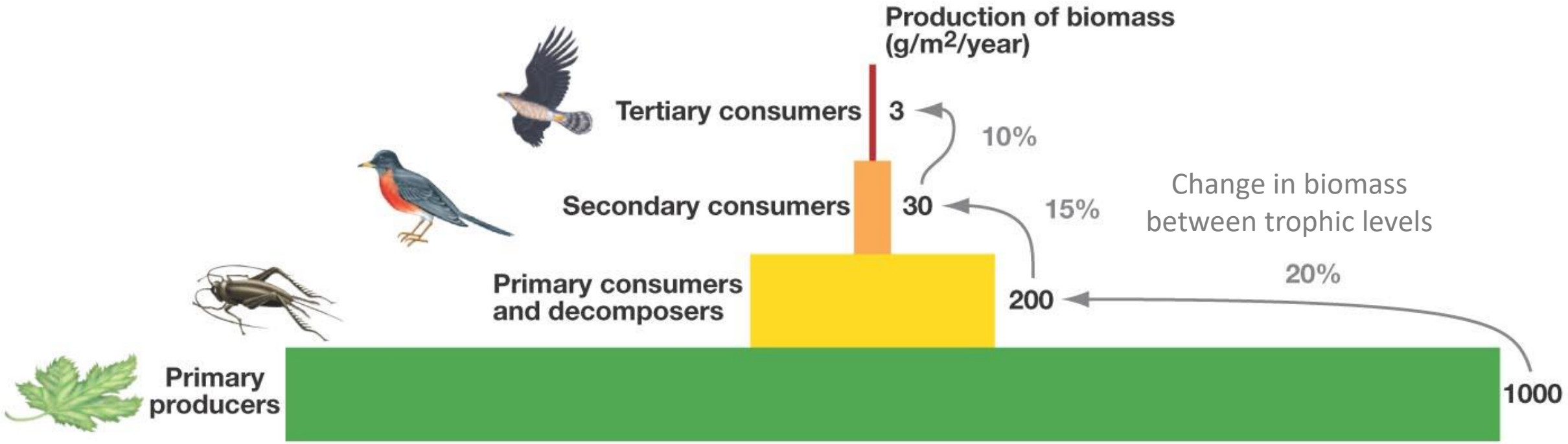
- Energy used for hunting, etc.



Loss of energy between trophic levels creates a **biomass pyramid**

Due to energy loss, it takes MANY primary producers to support only a few tertiary (3°) consumers.

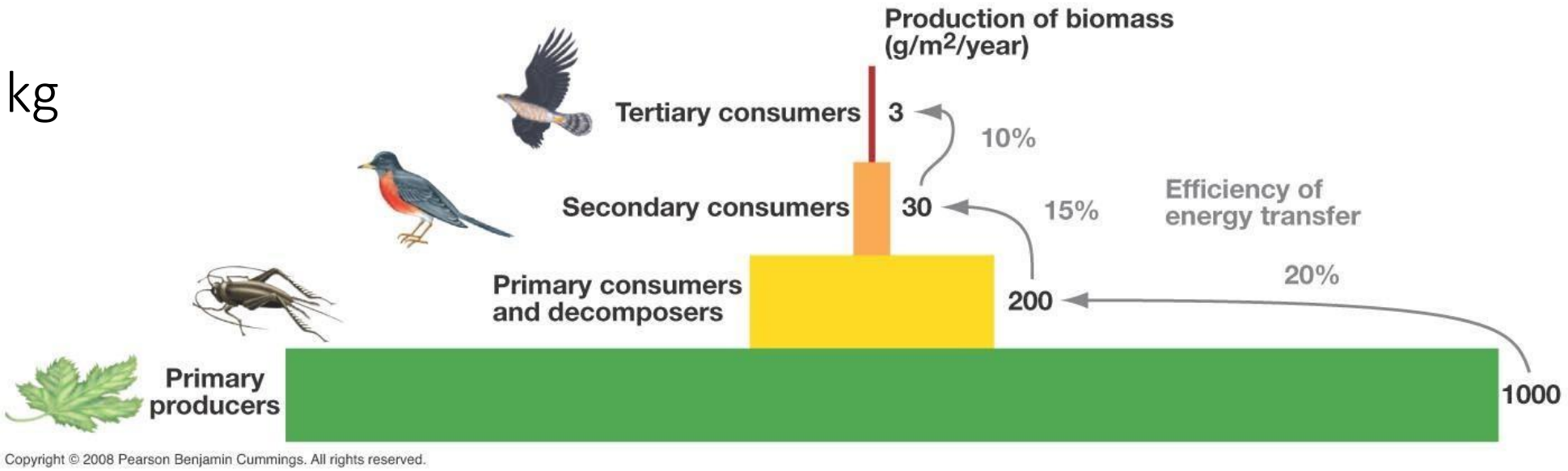
Why big, fierce animals are rare ☺.



iClicker Question

Given the 10% rule, approximately what biomass of tertiary consumers would be supported by 10,000 kg of producers?

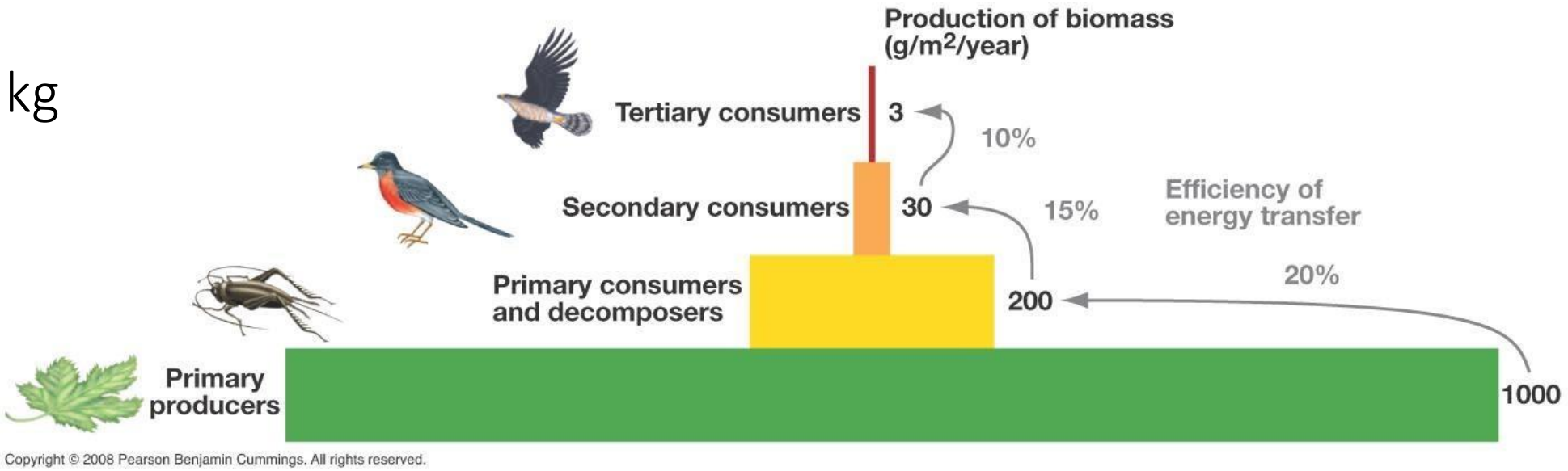
A. 100 kg
B. 1000 kg
C. 10 kg
D. 100,000 kg
E. 0 kg



Answer

Given the 10% rule, approximately what biomass of tertiary consumers would be supported by 10,000 kg of producers?

A. 100 kg
B. 1000 kg
C. 10 kg
D. 100,000 kg
E. 0 kg



Short activity

You collected data on the biomass of multiple taxa within an ecosystem. Identify trophic level (e.g. 1° consumer). You can assume ~10% energy loss between trophic levels. And, draw a food web.

Taxon	**Biomass (kg)**	**Trophic Level**
Land eel	806	
Wormsbane	82,100	
Jackalope	7994	
Vampire unicorn	820	
Flying orpsicle	78	

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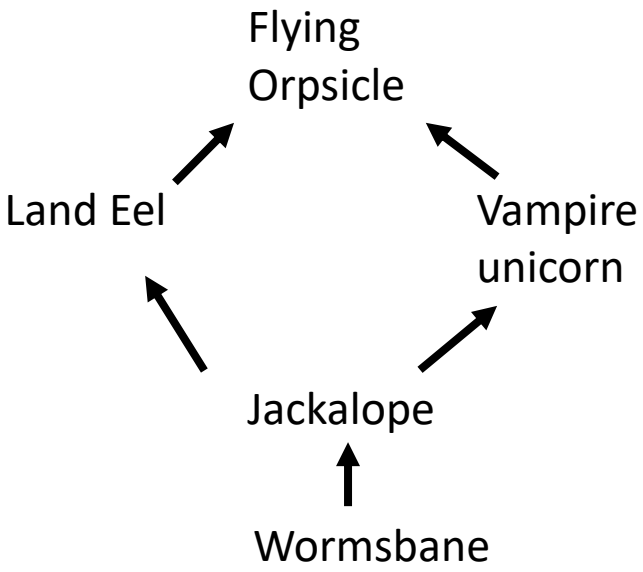

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Add a detritivore to this food web (e.g. Gummy worm)

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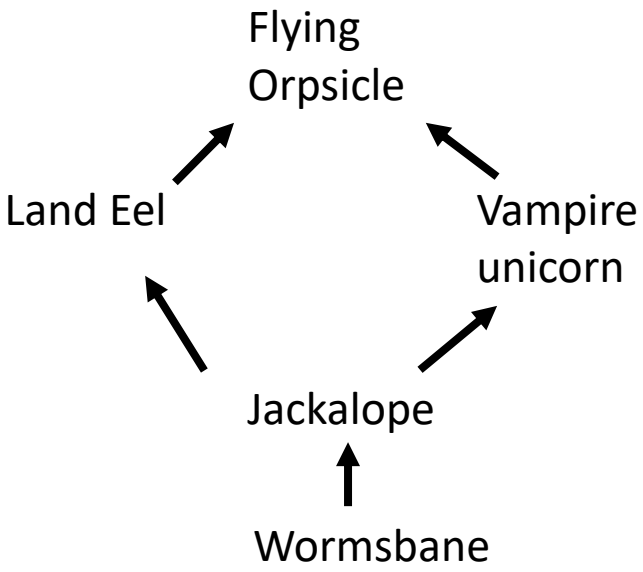

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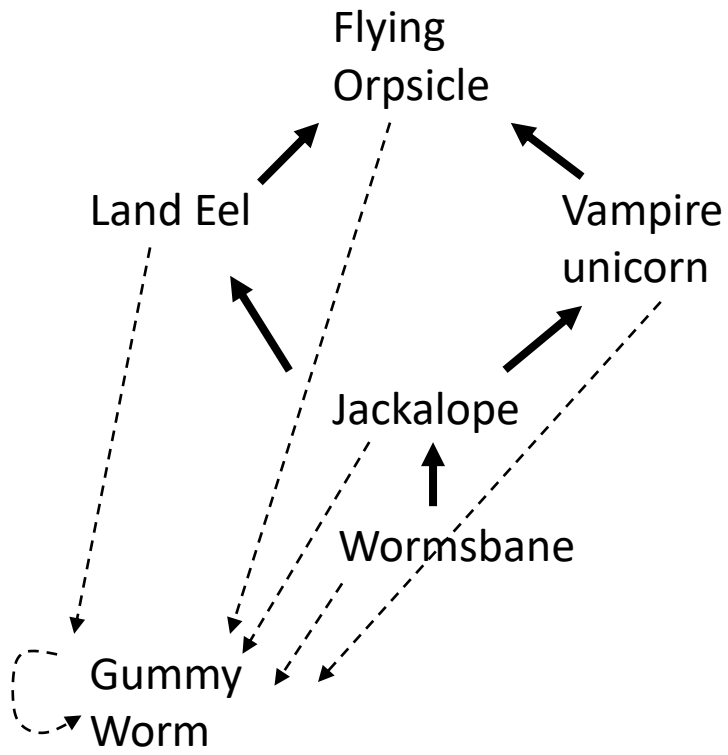

Learning goal (energy flow)

- Be able to describe the flow of energy through a food chain or food web and predict the consequences of changes to the system.

Next class, and due this Sunday

Next Class (Tuesday)

- Dr. Pam Kalas will visit class to discuss Genetic Survey, Round II (1%)
- Ecosystem Ecology: Finish Energy Flow (perturbations to food web) & Nutrient Cycling
    - Nitrogen Cycle & Great Bear Rainforest
- If time (big if) – Rory will give a short lecture on his research

Final Deadline for Group Project – this Sunday @ 11:59 pm