Integrating student understanding of ecological flows through concept mapping

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A scientist among creatives

I have taught courses in:

- ★ Ecology
- ★ Evolution
- ★ The Evolution of Cooperation
- ★ The Evolution of Sex
- ★ The Evolution of Play
- ★ The Evolution of Music
- ★ Behavioral Ecology
- ★ Human Evolution

Pratt

School of Liberal Arts & Sciences
Department of Mathematics & Science

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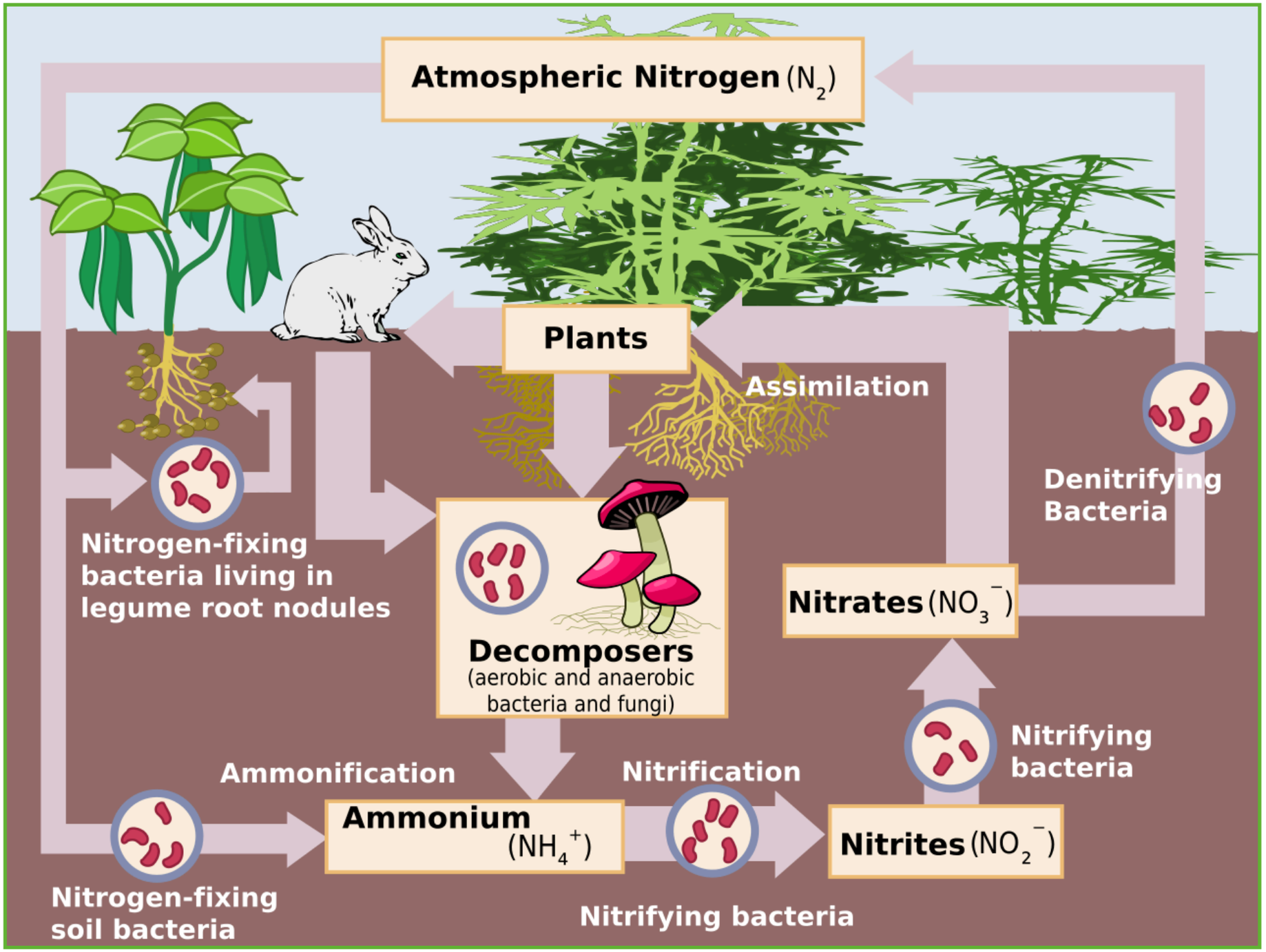
What we teach our students about ecological flows:

N



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What we teach our students about ecological flows:

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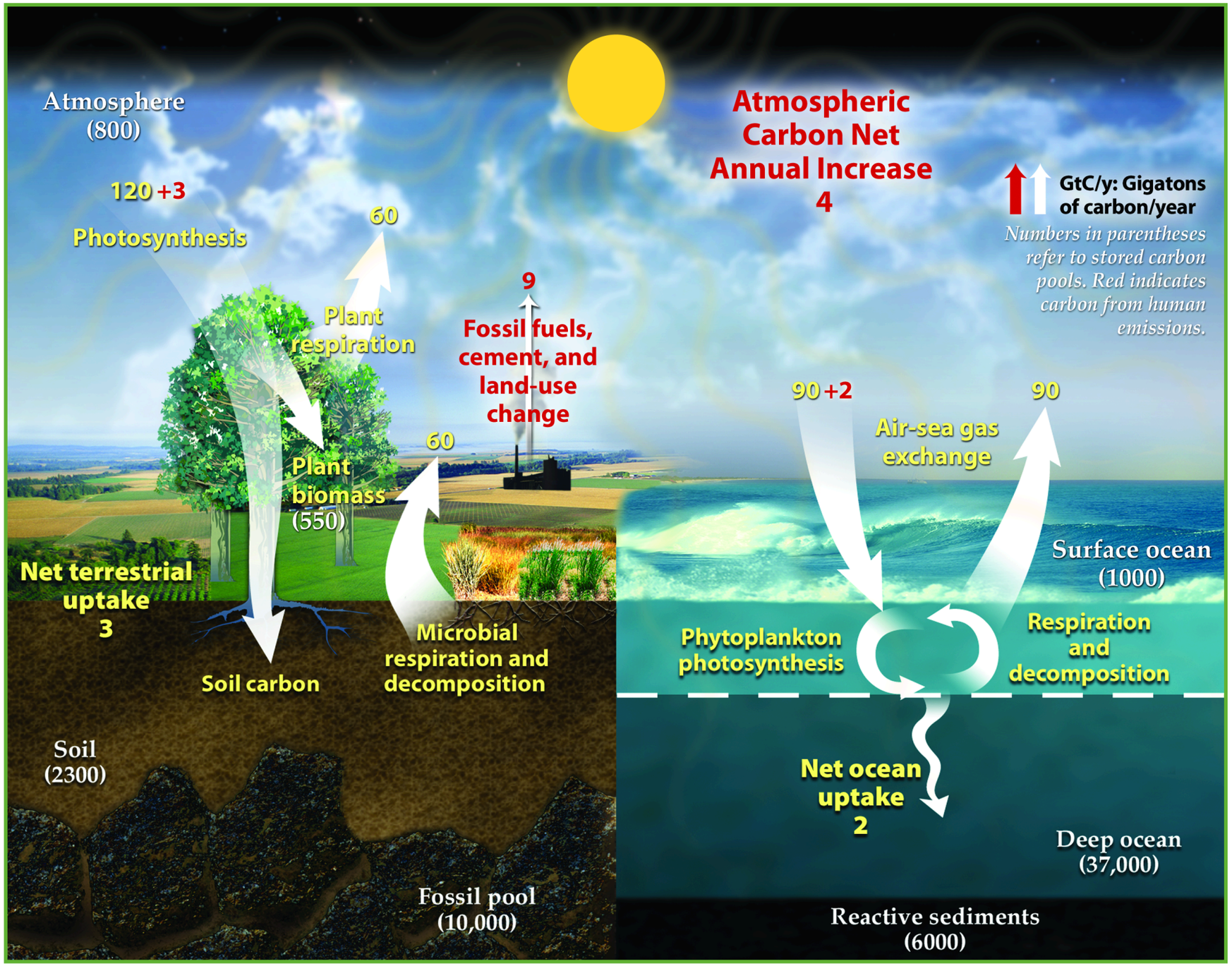

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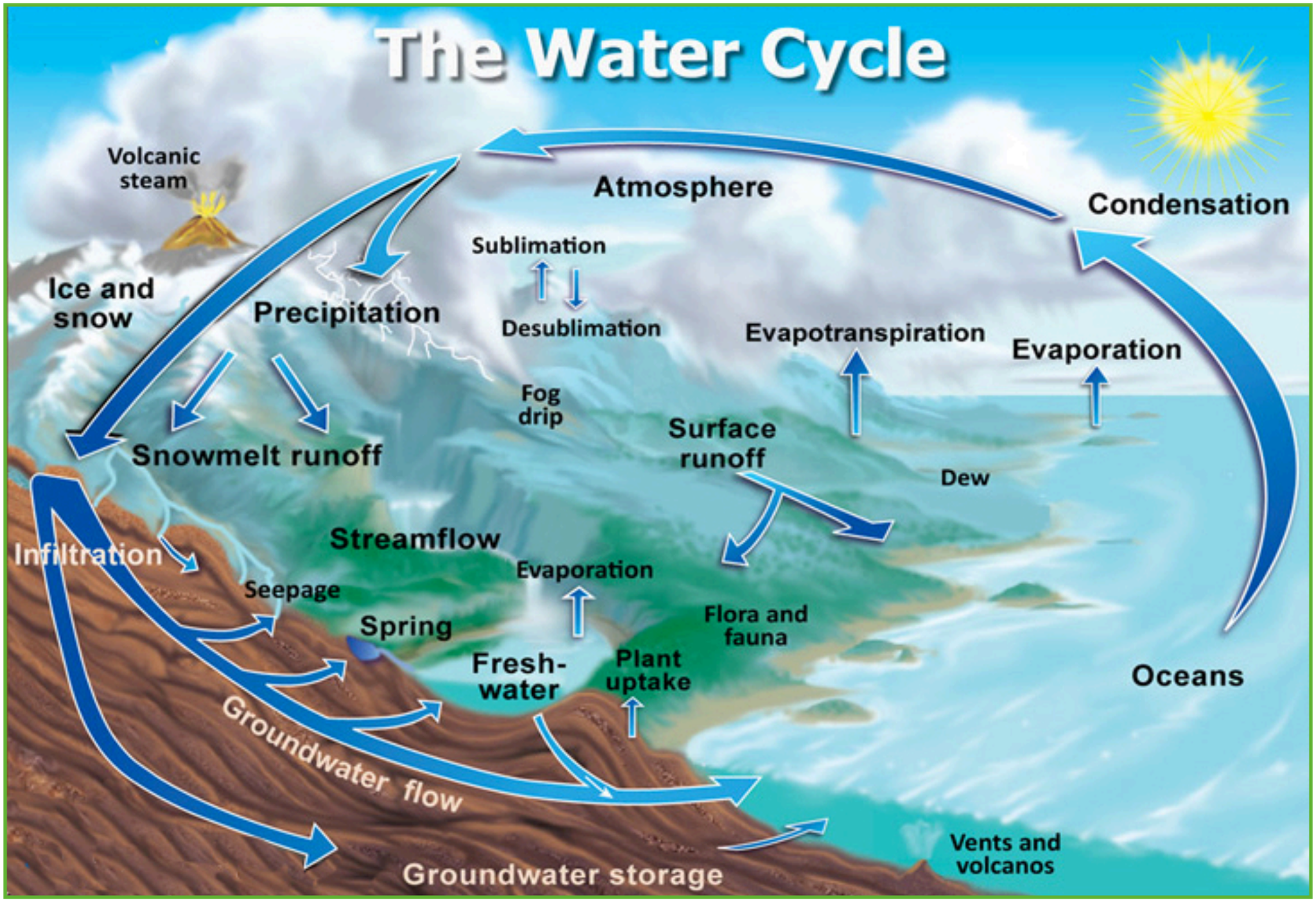
What we teach our students about ecological flows:

H_2O



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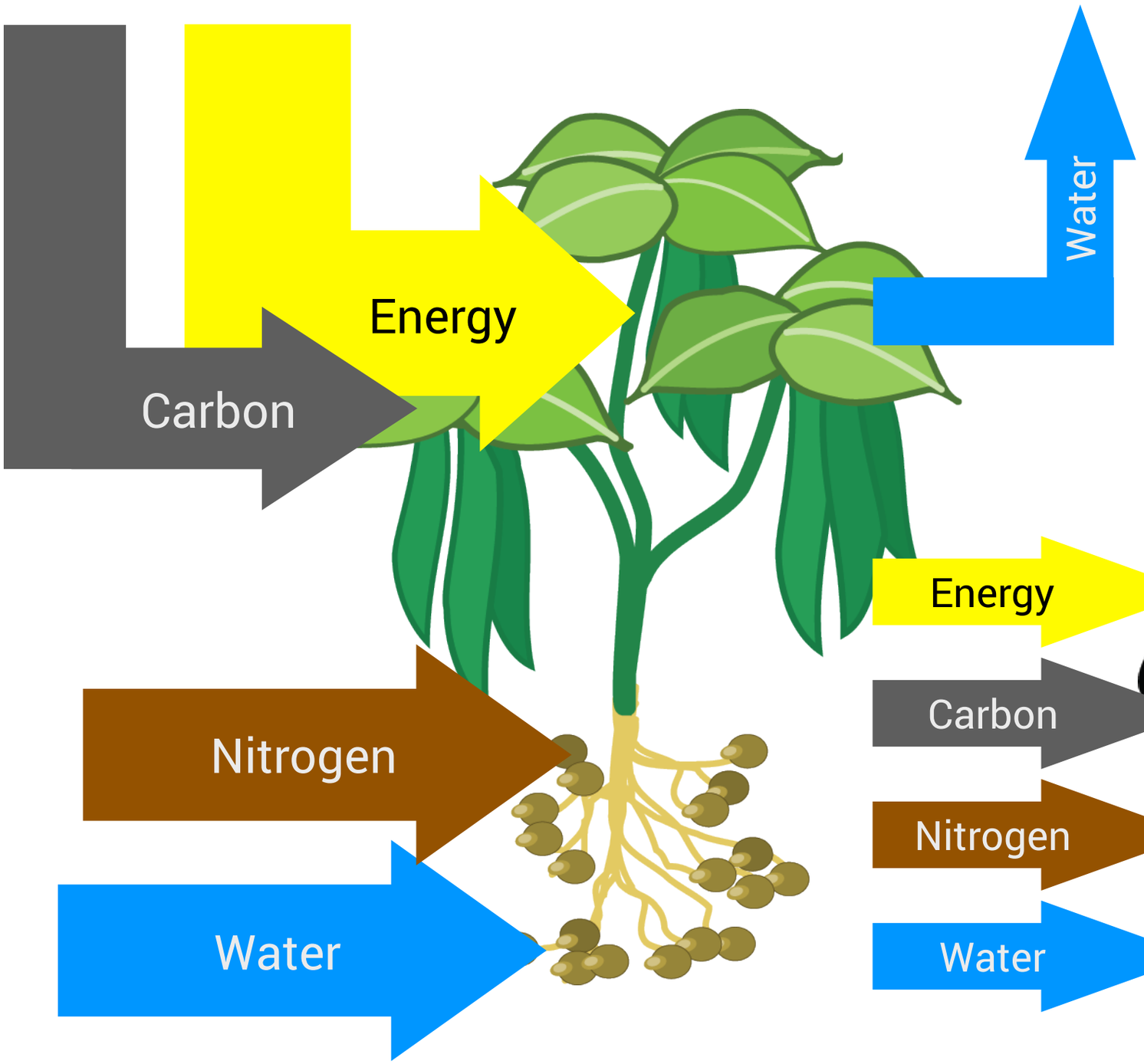
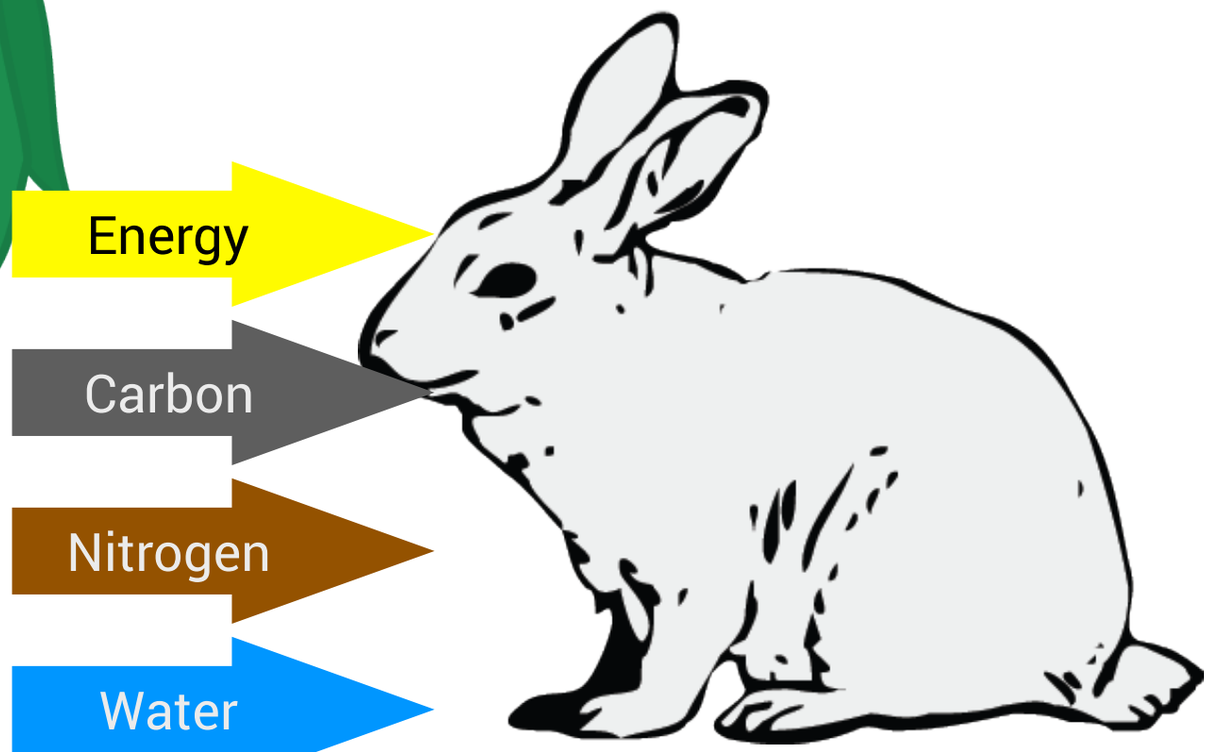
Ecological flows are actually integrated:



Example:

Herbivory



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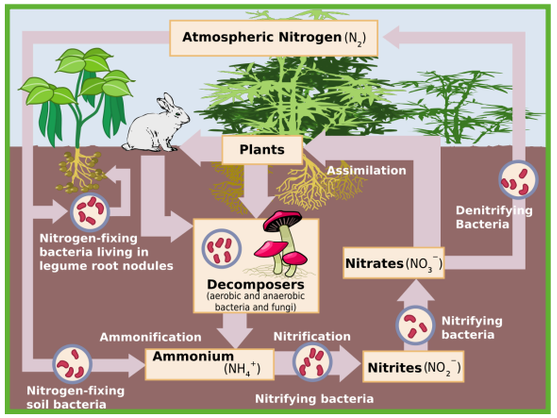
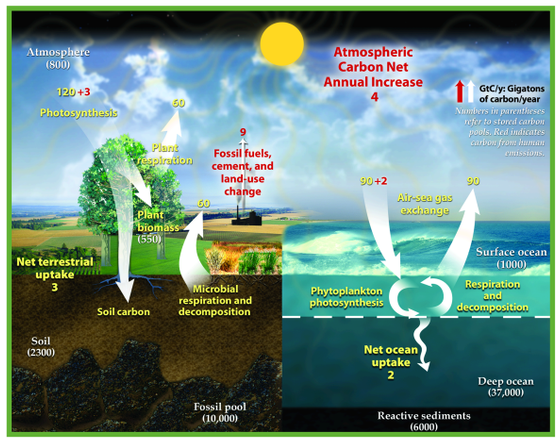
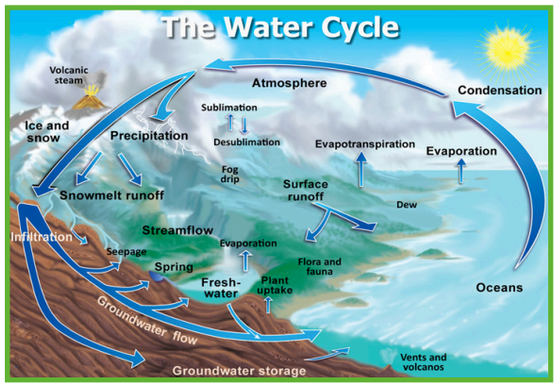
Problems with disintegrating ecological flows:







- ★ It is very easy for students to “memorize the diagram” rather than considering how a particular flow relates to ecological interactions & activities
- ★ Students don’t come to understand that fundamentally, ecological interactions and activities have a simultaneous effect on all of these cycles
- ★ The role that energy plays in these cycles is not depicted, so students fail to consider flow of energy
- ★ Disintegrating these cycles makes it harder for students to understand concepts like trophic inefficiency or human impacts on geochemical cycles

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An in-class activity to foster understanding of the integrated nature of ecological flows:

Group Activity: **The inter-relationships between ecological cycles**

Objectives of this Activity:

1. Consider how cycles of matter (carbon, nitrogen, and water) and flows of energy are inter-related in ecosystems;
2. Do appropriate web research to better understand how these cycles/flows are inter-related;
3. Construct a concept map — designed to teach others — that explicitly shows how these cycles/flows are inter-related; and
4. Present your concept map to the rest of the class so that we can:
   a. discuss how these ecological flows are inter-related; and
   b. compare and contrast different ways of representing information on a concept map.

Instructions:

1. Discuss in your group how cycles of matter (carbon, nitrogen, and water) and energy are inter-related in ecosystems.
2. Based on your discussion, identify any questions or confusion you have about the inter-relationship of these cycles.
3. As needed, do web research to answer questions and clear up confusion. Make sure to take note of the source of all information you gather.
4. Using VUE software, construct a concept map that is capable of teaching someone else how these cycles/flows are inter-related. At the very least, your concept map should:
   a. Represent the major biotic and abiotic components of the earth that relate to ecological cycling.
   b. Show how matter and energy flows through each of these cycles (in other words, there should be at least four identifiable "flows" in your diagram).
   c. Show how ecological interactions (e.g. predation, parasitism, mutualism, competition, or commensalism) and other ecological activities (e.g. photosynthesis, respiration, excretion/elimination, decomposition) are involved in these cycles.
   d. Clearly demonstrate where and how these cycles are inter-related.
   e. Label or otherwise demarcate which components on your map belong to the biosphere, lithosphere, hydrosphere, & atmosphere (*please note* that trying to represent these spheres as "nodes" won't lead to a successful concept map).
   f. Where appropriate, indicate the source of information represented on the map.
5. Present your map to the class, explaining what ideas your group wanted to show and how you designed your map to show these ideas.

[SEE OPPOSITE SIDE FOR INFORMATION ON HOW TO USE THE *VISUAL UNDERSTANDING ENVIRONMENT* CONCEPT-MAPPING SOFTWARE]

I am happy to share this activity with anyone who wishes to use it in their classroom.

Contact me at:

cjensen@pratt.edu

Objectives I ask my students to meet:

- ★ Consider how cycles of matter (carbon, nitrogen, and water) and flows of energy are inter-related in ecosystems;
- ★ Do appropriate web research to better understand how these cycles/flows are inter-related;
- ★ Construct a concept map — designed to teach others — that explicitly shows how these cycles/flows are inter-related; and
- ★ Present your concept map to the rest of the class so that we can:
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  - compare and contrast different ways of representing information on a concept map.

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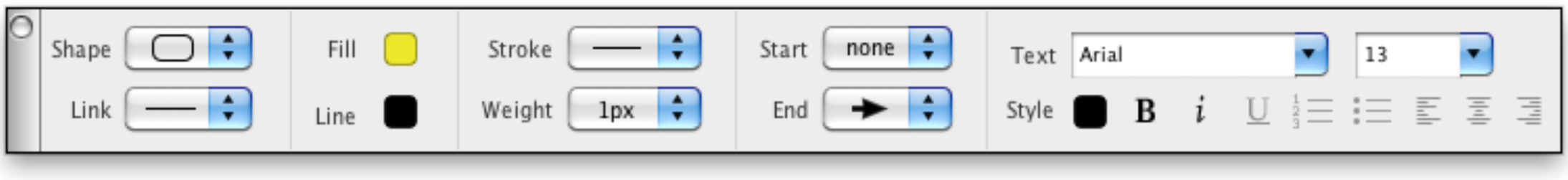
The concept mapping tool:

Visual Understanding Environment: *a free concept mapping application produced at Tufts University*

http://vue.tufts.edu/



Learning from what my students have produced:

★ Maps were created over a four year period in two different ecology-based courses

★ Analyzed 59 concept maps, each created by a single group of students

★ Each map was assessed based on how well it represented a variety of ecosystem-level flows, interactions, and components.

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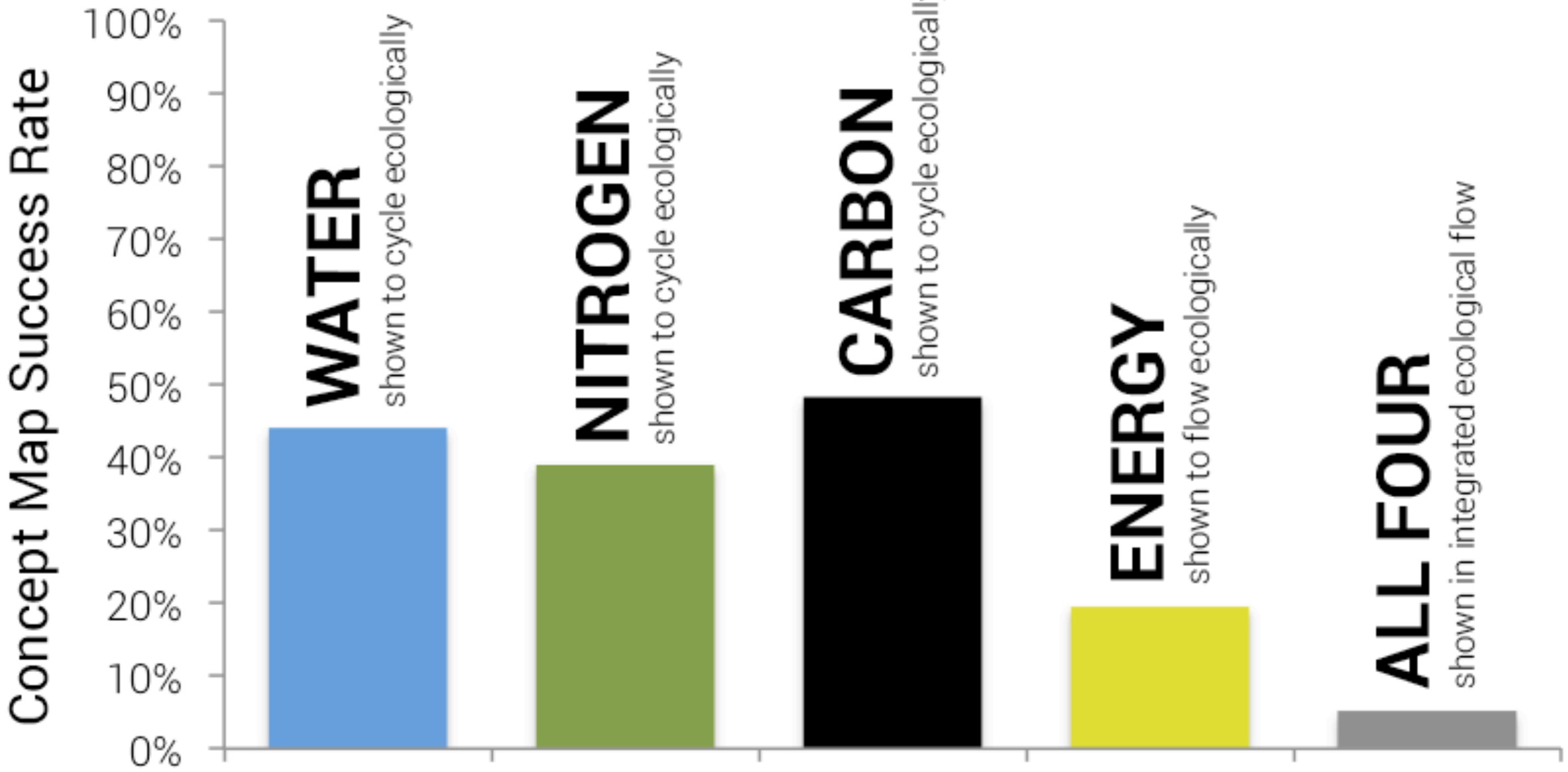
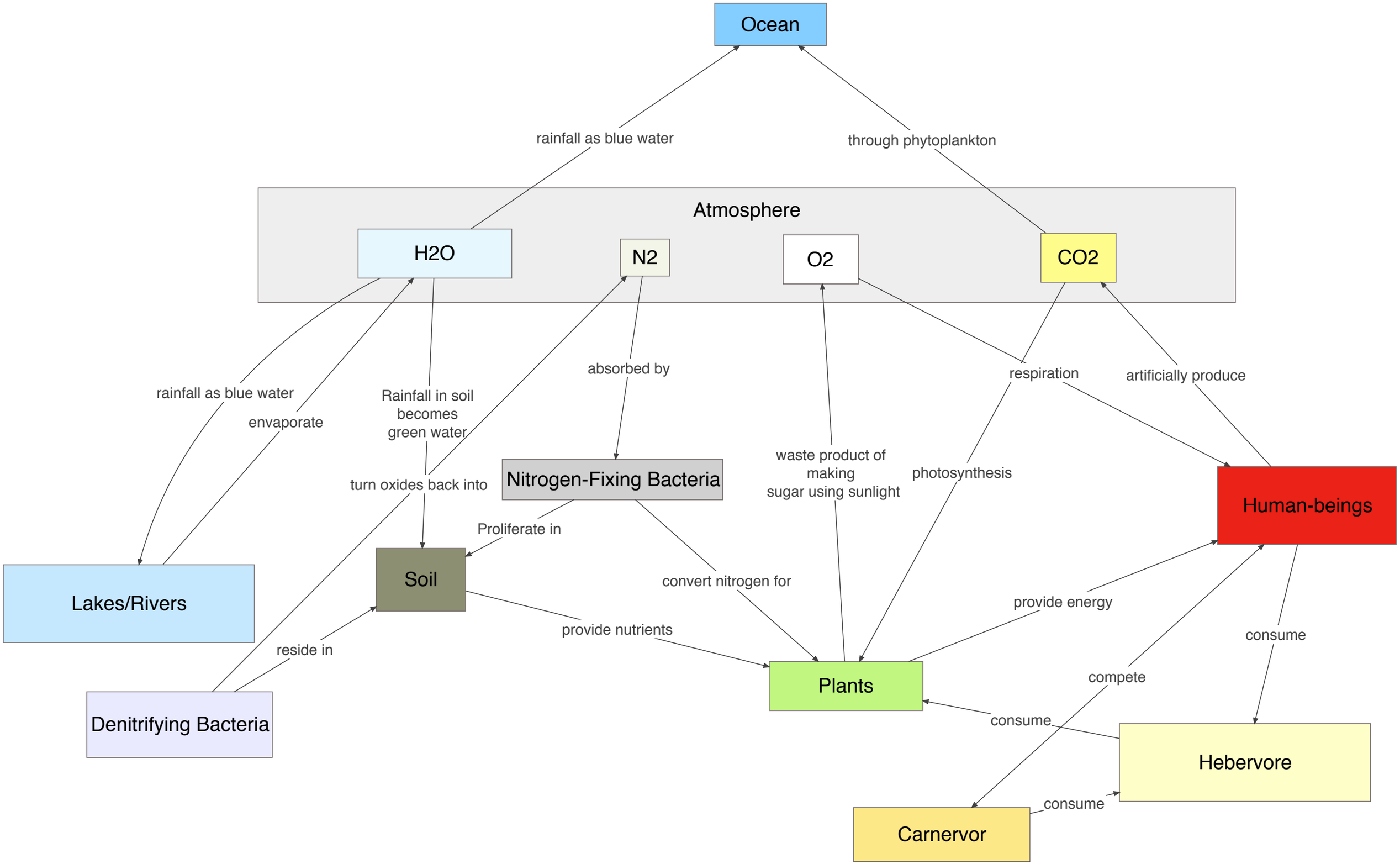
How well do students represent ecological flows?




Ocean
rainfall as blue water
through phytoplankton
Atmosphere
H2O
N2
O2
CO2
rainfall as blue water
envaporate
Rainfall in soil
becomes
green water
absorbed by
respiration
artificially produce
turn oxides back into
Nitrogen-Fixing Bacteria
waste product of
making
sugar using sunlight
photosynthesis
Human-beings
Proliferate in
Lakes/Rivers
Soil
convert nitrogen for
provide energy
consume
reside in
provide nutrients
Plants
compete
Denitrifying Bacteria
consume
Hebervore
consume
Carnervor

KEY

Nitrogen

Water

carbon

Energy

SUN

Atmosphere

Rain

Evaporation

Respiration

Nitrogen fixing bacteria

Drinking

Denitrifying bacteria

Bodies of water
(Hydrosphere)

Animals
(Biosphere)

Respiration

Photosynthesis

Decomposition

Consumption

Decomposition

Consumption

Runnoff

Urine, sweat, etc.

Consumption

additional nitrogen to soil

Soil
(Lithosphere)

absorbed by plants

absorbed by plants

Plants
(Biosphere)

Decomposition

Decomposition

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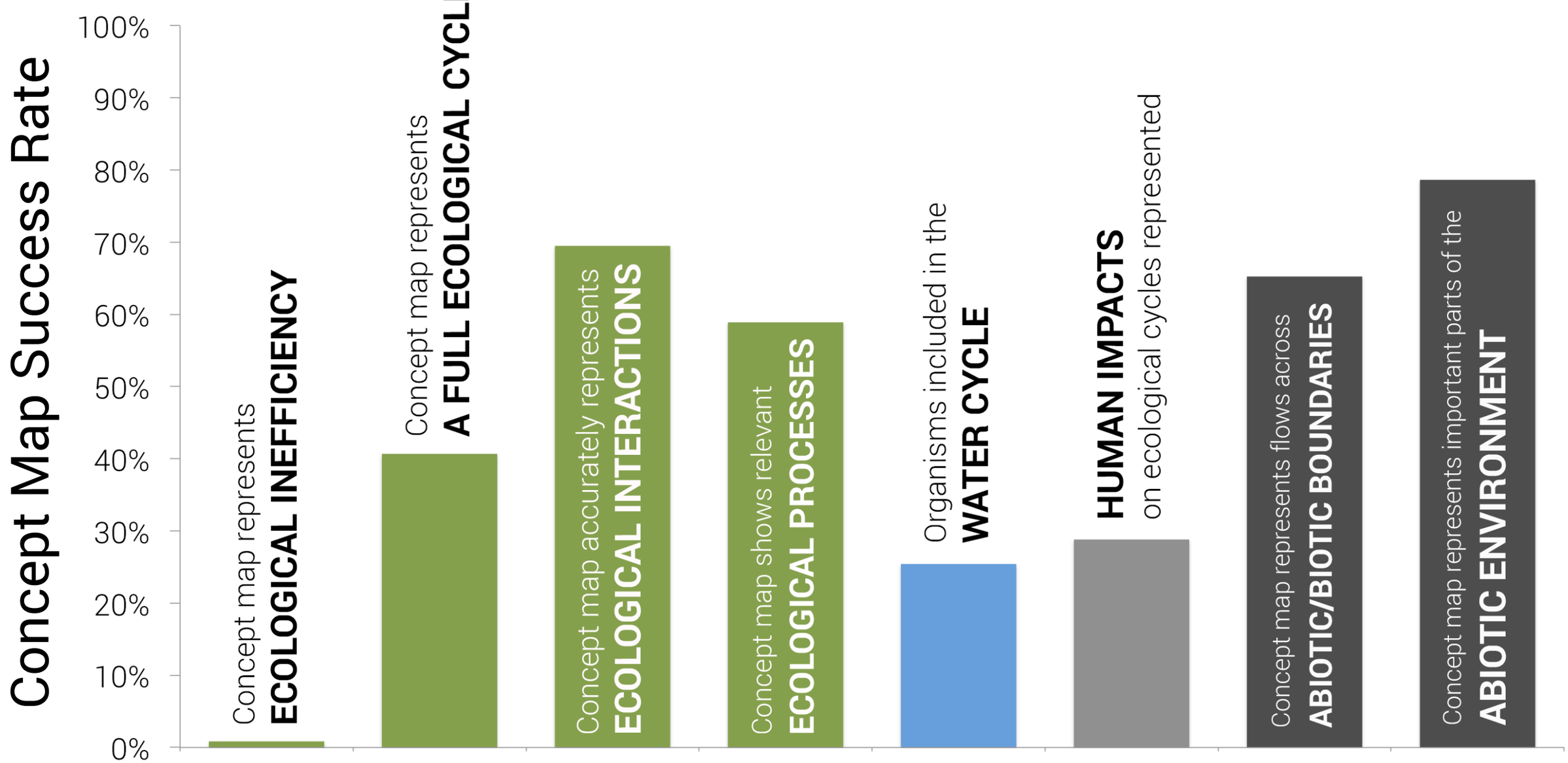
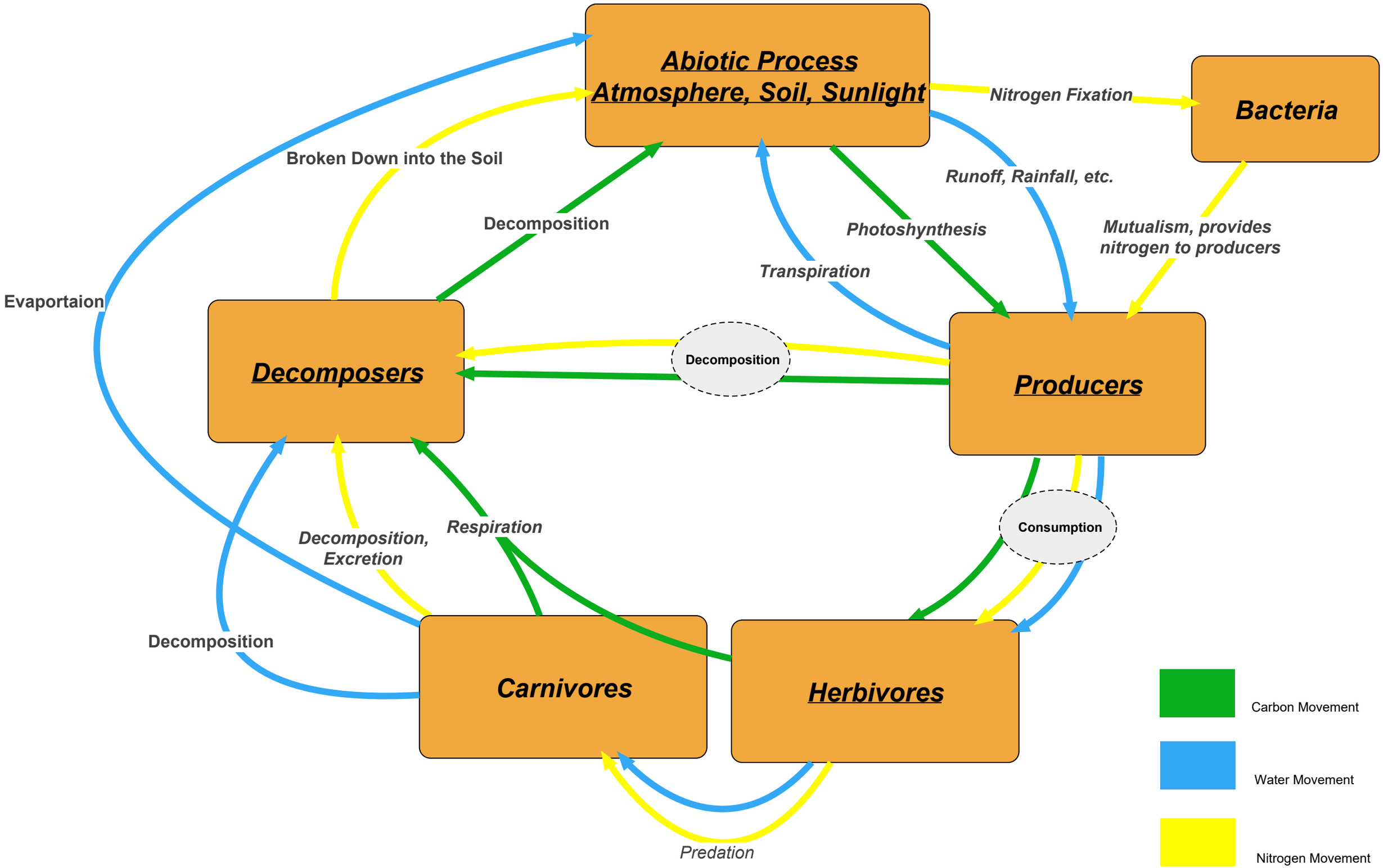
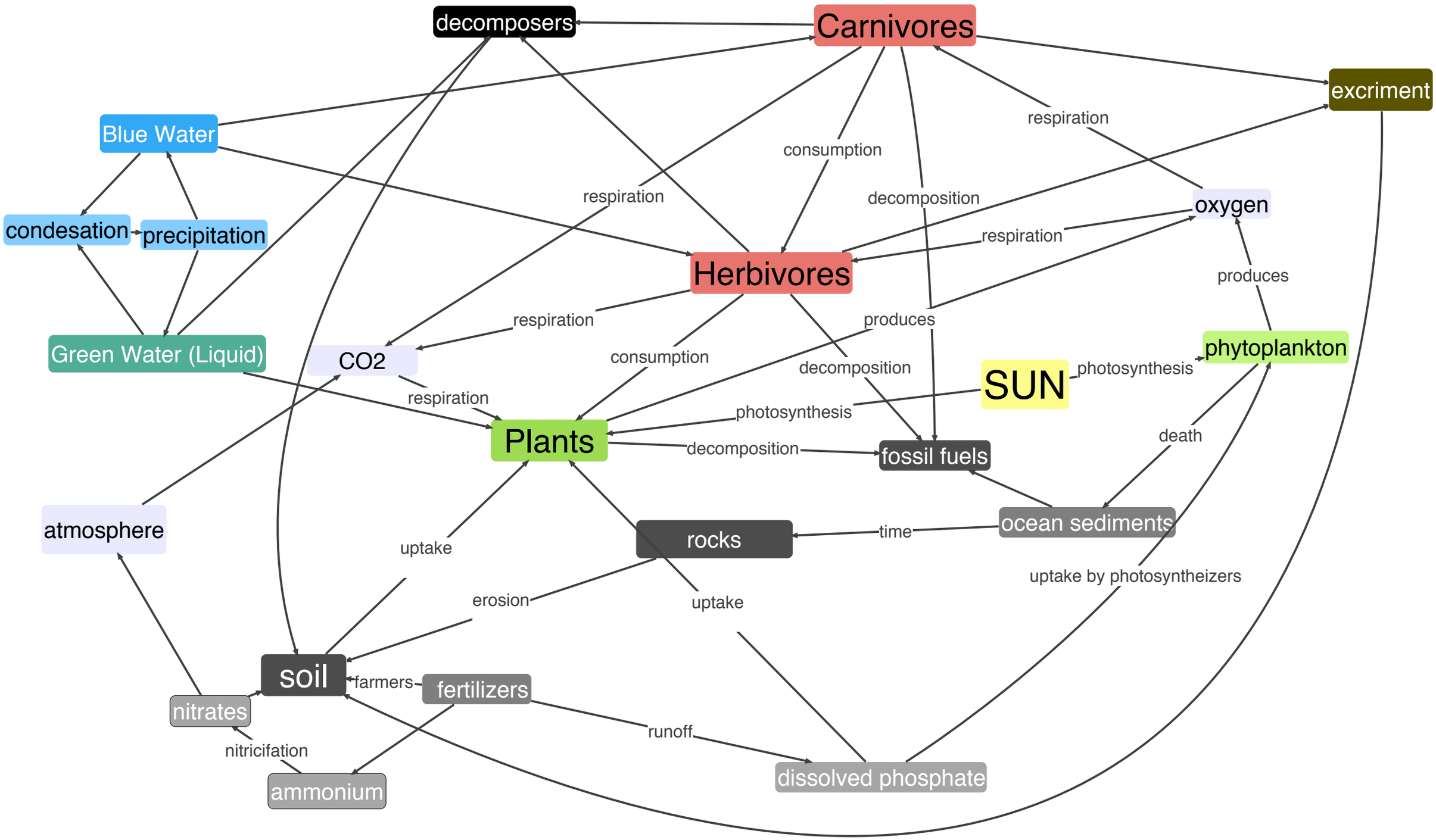
How well do students represent ecological systems & interactions in their concept maps?




Abiotic Process
Atmosphere, Soil, Sunlight
Nitrogen Fixation
Bacteria
Broken Down into the Soil
Runoff, Rainfall, etc.
Decomposition
Photoshynthesis
Mutualism, provides nitrogen to producers
Transpiration
Evaportaion
Decomposers
Decomposition
Producers
Consumption
Decomposition, Excretion
Respiration
Decomposition
Carnivores
Herbivores
Predation
Carbon Movement
Water Movement
Nitrogen Movement


decomposers
Carnivores
excriment
Blue Water
respiration
consumption
respiration
decomposition
oxygen
condesation
precipitation
respiration
Herbivores
produces
respiration
produces
Green Water (Liquid)
CO2
consumption
decomposition
phytoplankton
SUN
photosynthesis
respiration
photosynthesis
Plants
decomposition
fossil fuels
death
atmosphere
uptake
rocks
time
ocean sediments
uptake by photosyntheizers
erosion
uptake
soil
farmers
fertilizers
nitrates
runoff
nitricifation
dissolved phosphate
ammonium

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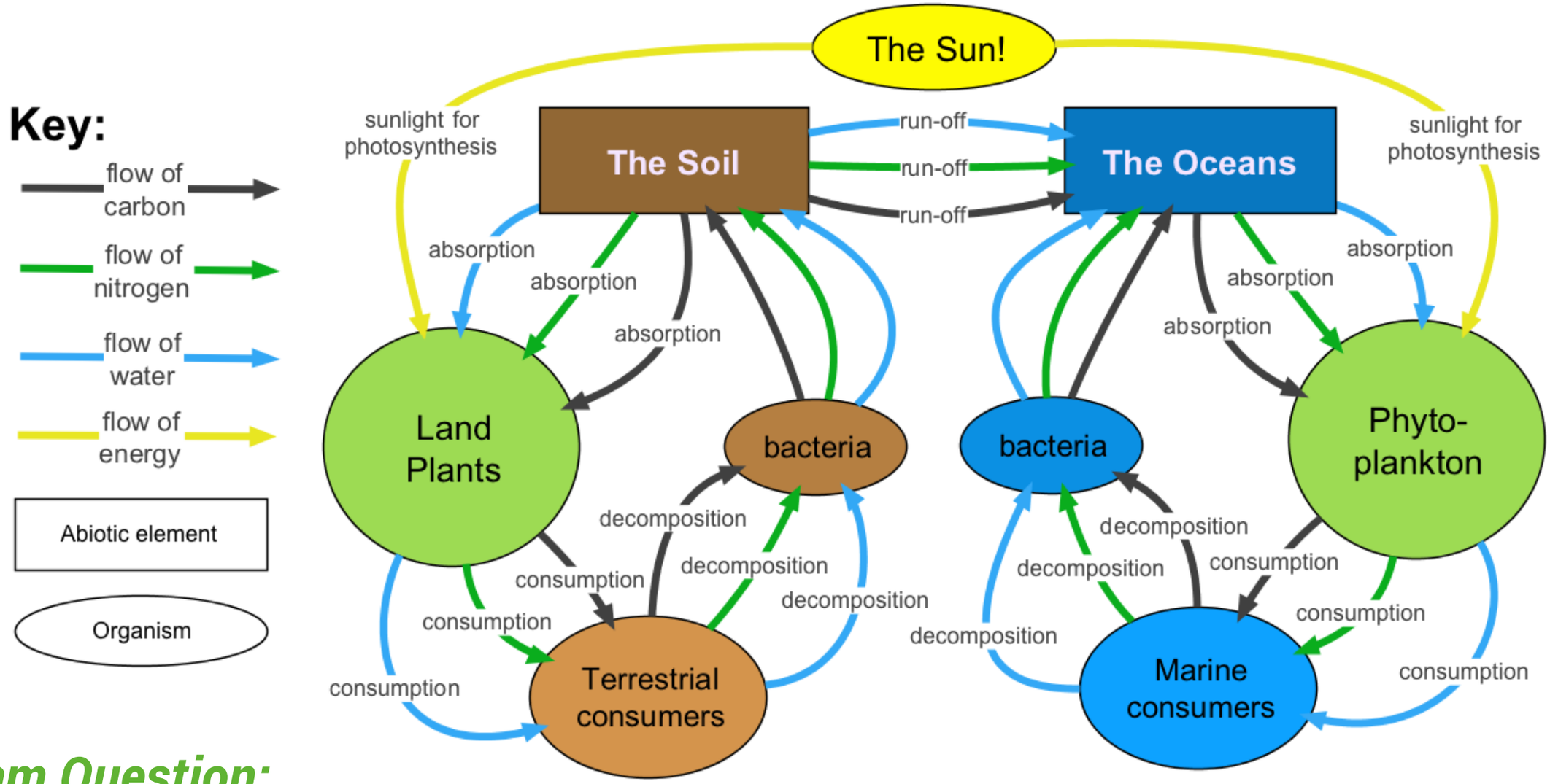
Does completing this activity improve student understanding of how ecological flows are integrated?



Exam Question:

*In terms of how this map **represents the inter-relationship between flows** of energy, water, carbon, and nitrogen in global ecosystems, **identify** at least four strengths & four weaknesses*

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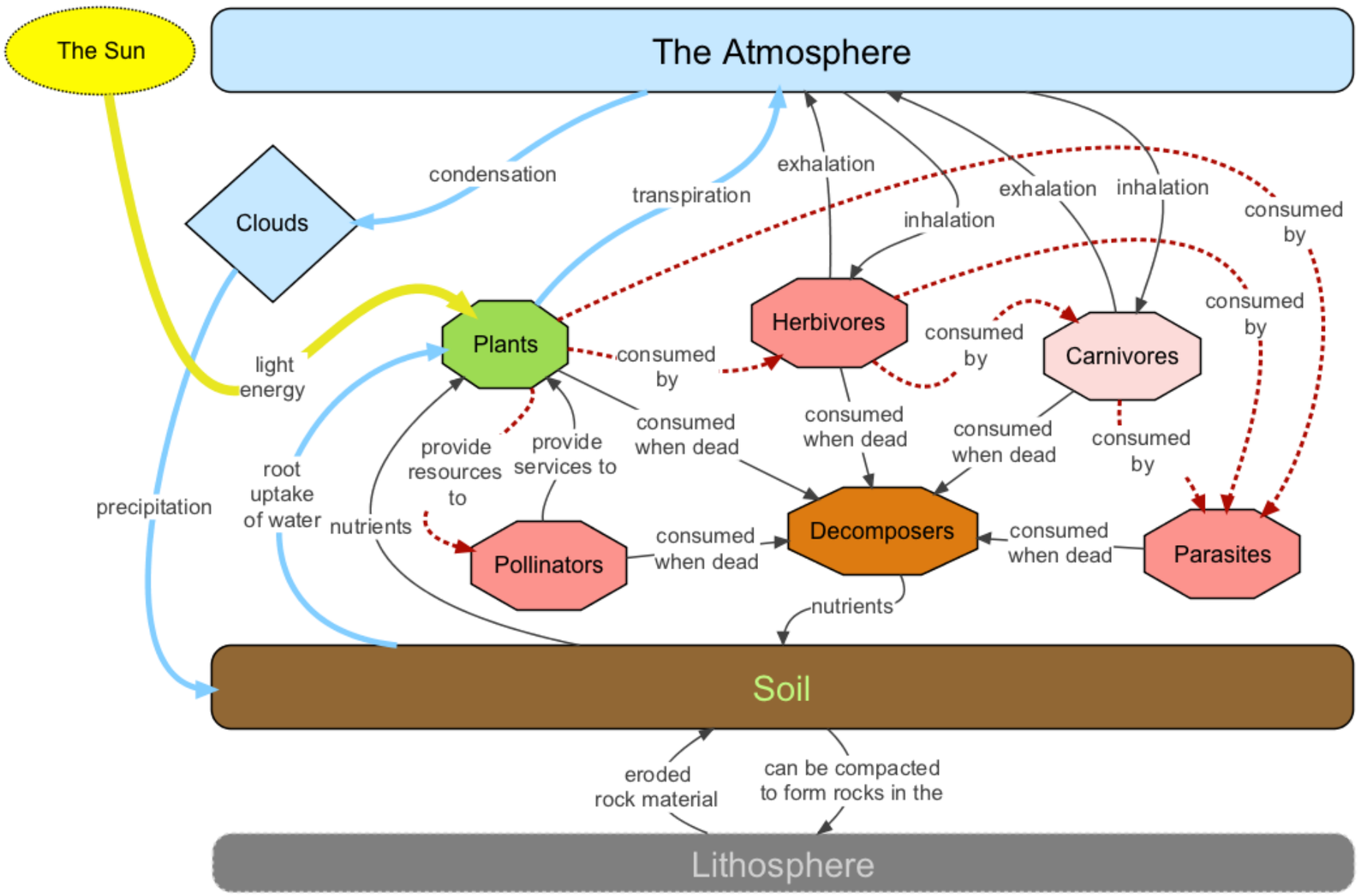

Exam Question:

In terms of how this map ***represents the inter-relationship between flows*** *of energy, water, carbon, and nitrogen in global ecosystems,* ***identify*** *at least four strengths & four weaknesses*

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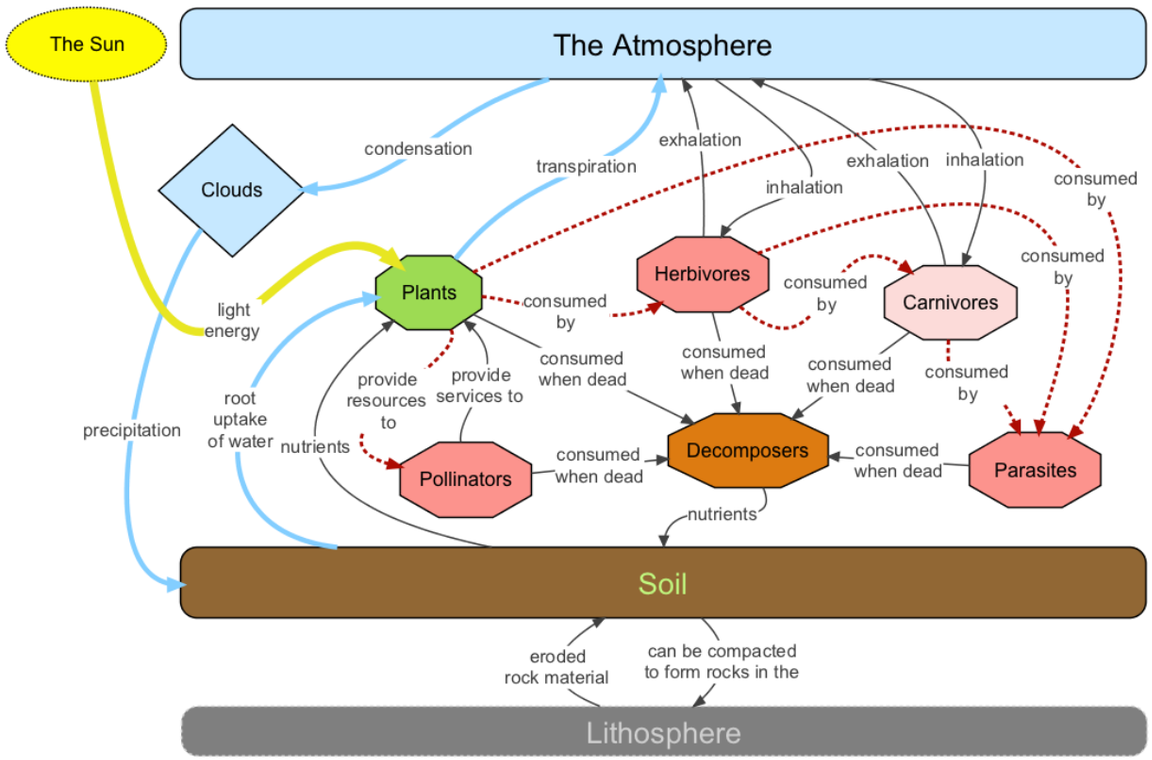
Strengths:

- ★ Represents the a variety of ecological interactions including parasitism, predation, and mutualism;
- ★ Shows how decomposers return nutrients to the soil and how plants absorb nutrients from the soil;
- ★ Has a complete cycle of water through the atmosphere, soil, and plants;
- ★ The sun is shown as the source of energy for this system;
- ★ Includes some important major abiotic parts of the earth (atmosphere, lithosphere) and how they interact with organisms and the soil;
- ★ The importance of inorganic rock material in soil formation is clear from this map, as is the way that organic materials in the soil can return to the lithosphere.



I am in the process of analyzing student answers in order to better understand the effectiveness of this concept mapping activity

Weaknesses:

- ★ The means by which water flows through ecological systems is not entirely clear in this map because it does not represent evaporation from soil;
- ★ The important role that plants play in absorbing atmospheric carbon dioxide is not clear in this map;
- ★ The full water cycle is not represented because bodies of water (lakes, rivers, oceans) are missing;
- ★ It is not clear on this map how carbon and nitrogen cycles because consumption is generically described;
- ★ The map vaguely explains gas flow between organisms and the atmosphere, but does not specify what elements are flowing;
- ★ It is not clear how energy flows in the map, as energy comes to plants and is not explicitly shown to flow anywhere else;
- ★ What form nitrogen, water, and carbon exist in the atmosphere is not clear.

Thank you!

I am happy to answer any and all questions!

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