Biodiversity & Ecosystems

Future of Agriculture Curriculum for Teaching Sustainability

Name: _____ Hour_____Date: _____

Date Packet is due:_____ Why late? _____Score: _____
Day of Week Date If your project was late, describe why

Overview: in this unit, you will be exploring how biodiversity enables ecosystems to provide services, and how levels of biodiversity and rates of biomass production relate to the resilience of an ecosystem. You will also be exploring the origins of biodiversity.

Main Questions

- What is an ecosystem and how do the interactions of living species and nonliving resources enable an ecosystem to function?
- How does the rate of biomass production relate to ecosystem function?
- How does the level of biodiversity relate to ecosystem function?
- How does the level of resilience of an ecosystem relate to its function?
- What are ecosystem services and why are they vital to the existence of humans and other species?
- How do genes and proteins relate to the levels of biodiversity in an ecosystem?
- How do the genes and proteins of a species relate to the risk of extinction of that species?

Weekly Schedule

Monday:
- Introduction to Ecosystems – Bioreactor Ecosystems
- Model development – how do ecosystems function?

Tuesday:
- Nutshell Video & Notes
- Class discussion & revisions of explanations

Wednesday:
- Bioreactor Ecosystems Lab
- Meadow Simulation Activity

Thursday:
- Review
- Group Quiz

Friday:
- Weekly Reflection
- Career Connections OR additional work time.

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MICHIGAN STATE UNIVERSITY

Semester Schedule

Week 1: Introduction & Lab Safety

Atoms to Ecosystems

Week 2: Matter & Energy
Week 3: Cell Biology
Week 4: Biodiversity & Ecosystems
Week 5: Biodiversity & Habitats
Week 6: Midterm Assessments

Causes of Extinction

Week 7: Extinction
Week 8: Habitat Loss
Week 9: Invasive Species
Week 10: Land & Water Pollution
Week 11: Atmospheric Pollution
Week 12: Overharvesting
Week 13: Midterm Assessments

Sustainable Societies

Week 14: Natural Resources Management
Week 15: Societies & Sustainability
Week 16: Individual Sustainability
Week 17: Personal Campaigns
Week 18: Personal Campaigns

Day 1: Bioreactor Ecosystems

Introduction: In this activity, you will be using a FACTS Bioreactor (or a sealed glass beaker or jar) to create a simplified ecosystem that will help you to better understand the relationships between living species and nonliving resources that enable an ecosystem to function. If you do not already have a bioreactor ecosystem set up, see the appendix for specific directions on how to do so.

An *ecosystem* is a term used to describe how living organisms interact with each other and with the nonliving components in a given area. Your bioreactor ecosystem is a tiny model that helps us to understand how much larger and more complicated ecosystems function. Your bioreactor ecosystem should contain only three kinds of organisms. The most obvious organisms are the brine shrimp. You should be able to see these tiny animals swimming throughout your ecosystem if you look closely. Less obvious are the phytoplankton. These are single-celled organisms that are similar to plants and can *photosynthesize* (or convert CO_2 and H_2O into glucose and oxygen using the energy of sunlight). Lastly, there are microbes in your bioreactor such as bacteria and microscopic fungi. These microbes will break down the biomass of the shrimp, phytoplankton, and other microbes when they die.

A brine shrimp individual.
Source: Wikimedia Commons

Directions: As a group, observe your bioreactor ecosystem and use your observations. As a group, address the questions below using your observations to guide your thinking. Use a notebook, dry erase board, or scratch paper to record your ideas. Answer as many questions as you can. Be prepared to discuss as a class.

Questions:

1. Briefly summarize all of the transformations of matter and energy that are occurring in this bioreactor.
    a. What forms of energy (light, motion, chemical, or heat) are present in this bioreactor ecosystem?
    b. What are some examples of energy transformation in this ecosystem?
    c. How is biomass being created from inorganic molecules in this bioreactor ecosystem?
    d. In what ways is biomass being converted back into CO_2 and H_2O in this ecosystem?
2. Your bioreactor ecosystem should be sealed so that air cannot be exchanged with the outside environment. Will your ecosystem run out of oxygen? Why or why not?
3. What is more important to the function of this ecosystem – the phytoplankton or the shrimp? Why?
    a. Could one exist without the other? Explain.
    b. Which do we need more of – the phytoplankton or the shrimp? Why?
4. *Biodiversity* is a term used to describe the variety of different species in an ecosystem.
    a. Is your bioreactor ecosystem very biodiverse? Explain.
5. A *resilient* ecosystem is one that could recover from a disturbance and still function.
    a. Do you think that this bioreactor ecosystem is resilient? Why or why not?
    b. How might the level of biodiversity in your ecosystem affect the resilience of that ecosystem?
6. *Ecosystem services* are the benefits that an ecosystem can provide. These can include nutrient cycling, oxygen production, water purification, and food production.
    a. How do you think that the level of biodiversity and level of resilience in your ecosystem affects the ability of your ecosystem to provide these services?

Day 2: Notes & Discussion

Introduction & Directions: In this activity, you will begin by watching a short video about ecosystems. This will help to clarify some of the questions you may have had yesterday. After the video, you will look at a short slideshow presentation that will provide you with specific information about how ecosystems function. Your instructor may decide to deliver the presentation as a classroom lecture or they may allow you to read the notes individually or in small groups (depending on your previous experience and capabilities with this content). After you have watched the video and finished with the slideshow, you will work in small teams to answer the questions listed below. You should take notes in a notebook, on a dry erase board, or on scratch paper so that you are prepared to deliver your responses during the class discussion that will follow. *Note: your instructor may assign your group to answer specific questions if time is limited.*

URL Links
YouTube Video: https://youtu.be/eGG7hyx_HlA

Slideshow Presentation: https://www.factsnsf.org/uploads/1/4/0/9/14095127/2018-1-19_facts_evol___biodiv___ecoservices.pptx (*or visit www.factsnsf.org and use the menu bar*)

Discussion Questions:

1. Briefly summarize how living species such as plants, animals, and decomposers interact with each other and the non-living components of their environments. Include the following terms: producers, consumers, CO_2, H_2O, sunlight, plants, animals, decomposers.
2. Why do environments that are sunnier, warmer, and wetter typically have larger numbers of species than environments that are darker, colder, and drier? How does this relate to the 10% Rule?
3. Briefly summarize the three kinds of biodiversity. Then define *ecosystem resilience* and explain how biodiversity and ecosystem resilience are related.
4. What are *ecosystem services*? What are examples of the four kinds of ecosystem services? How do biodiversity, ecosystem resilience, and ecosystem services affect each other?
5. Why should humans care about biodiversity, ecosystem resilience, and ecosystem services? How do these concepts affect the daily lives of people? What happens to people if these items are impaired?
6. Are some species in an ecosystem more valuable than others? Use the terms *producers* and *keystone species* in your answer.
7. How does the function of a human-managed ecosystem differ from that of a naturally-occurring ecosystem? What are the advantages and disadvantages of having human-managed ecosystems?
8. All species exhibit different traits. Why? Briefly summarize the source of the different traits exhibited by living species. In your answer, include the following: genes, proteins, DNA.
9. Where does biodiversity come from? Explain how new species emerge by describing the changes to DNA that occur as a result of mutations, natural selection, and evolution.
10. Why do some species disappear? Explain how extinctions occur as a result of environmental changes.

Day 3: Lab Activity

Introduction: you will be completing two activities today. The first involves re-visiting your bioreactor ecosystems. You will once again look at the questions on page 2 and see if you are better capable of addressing them. In particular, pay attention to whether or not your answers might have changed since Monday. The second activity requires you to use a computer simulation to explore how changing populations of producers and consumers affects the stability and composition of a hypothetical ecosystem. Your instructor may choose to demonstrate how this program works for the entire class before letting you work in your groups.

Directions:

1. Begin by re-observing your bioreactor ecosystems and re-visiting the questions on page 2.
    a. Briefly address each question as a team.
    b. Are you better able to answer these questions now than the first time you tried?
    c. How have your answers changed since you first saw these questions?
2. Next visit the meadow computer simulation at http://media.bscs.org/carbontime/simulations/meadow-simulation/index.html[1].
3. Access the worksheet online for this simulation at http://media.bscs.org/carbontime/ecosystems/worksheets_assessments/2.2_Meadow_Simulation_Worksheet.pdf (*your instructor may have chosen to have made printed copies in advance*).
4. Complete the activity using the instructions in the simulation worksheet. If your instructor provides you with hard copies of the worksheet, complete the answers on the worksheet copy provided to you. If you are accessing the worksheet digitally, ask your instructor if written or oral answers are required.
5. After completing the meadow simulation activity, address the questions below as a group. Be prepared to provide your answers during a follow-up class discussion.

Questions:

1. What patterns did you notice in the amount of fox, rabbit, and grass biomass at the completion of each trial? How would you explain these patterns given what you know about ecosystems?
2. If a disease were to occur in this ecosystem and caused the number of grass plants to drop by 75%, what would happen to other species in this ecosystem? Why? How does this relate to the 10% rule?
3. If there were multiple species of grass, rabbits, and foxes, would biodiversity in this ecosystem increase or decrease? Would it be more or less resilient? Would the ecosystem services increase or decrease?
4. What would be necessary to occur in order for more species of foxes, rabbits, and grass to emerge over time? Summarize how this ecosystem could become more biodiverse via mutations & natural selection.
5. Could this ecosystem function without plants? Could it function without animals?
6. Are there any human activities that could *decrease* the biodiversity/ecosystem services/resilience of this habitat? Are there any human activities that could *increase* the biodiversity/services/resilience?

[1] *This simulation is part of the Carbon TIME biology curriculum. This resource is used with permission.*

Day 4: Review & Assessment

Directions: you will begin by reviewing the unit objectives in your small groups. For each objective, rank it as a 1 (*completely unsure*), 2 (*somewhat unsure*), or 3 (*completely sure*) based on your comfort with that objective. After a few minutes of review, your instructor will lead a whole-class review. This is your chance to ask any questions you still might have about the concepts in this unit. Begin with anything you ranked as a "1".

After you have completed the unit review, you will be taking an individual multiple choice quiz and/or a group short answer quiz. These quizzes may be graded in class to help you better understand the question and the correct answer.

Unit Objectives:

1. What is the definition of an ecosystem? What is required for something to be an ecosystem?
2. What are producers and what are consumers in an ecosystem? How does the presence of consumers and producers relate to the function of an ecosystem?
3. How does the climate of an area and the rate of biomass production affect the amount of producers and consumers that can exist in an ecosystem? How does this relate to the 10% rule?
4. What is biodiversity? How can you determine the level of biodiversity in an ecosystem?
5. What are ecosystem services? How does the level of biodiversity relate to the amount of ecosystem services that can be provided? Why should humans care about ecosystem services?
6. What is ecosystem resilience? How does the level of biodiversity relate to the resilience of an ecosystem? Why should humans care about ecosystem resilience?
7. What is a keystone species? How does the presence of a keystone species relate to ecosystem function, ecosystem services, and ecosystem resilience?
8. What is a human managed ecosystem? How does the function of a human managed ecosystem differ from a naturally-occurring ecosystem? How does the level of biodiversity and ecosystem services of a human managed ecosystem differ from a naturally-occurring ecosystem?
9. What is DNA? What are genes? What are proteins? What are mutations? How do these items relate to the visible traits of an organism? How do these items relate to the levels of biodiversity in an ecosystem?
10. How can more biodiversity be created through mutations, natural selection, and evolution?
11. What factors increase biodiversity in an ecosystem? What factors decrease biodiversity in an ecosystem?

Day 5: Career Connections

Directions: to begin this activity, you will form small groups (ideally, 3-4 individuals). These groups could either be your assigned lab groups from this week OR you could find 2-3 other individuals who have career interests that are similar to yours. Your instructor will inform you which option you will be using to form your groups.

Once you have formed your groups, address the following questions as a team.

1. Try to summarize everything that you have learned so far in this course within your group. Try to identify the common themes, major ideas, and most important concepts from the content you have learned.

2. Try to get a sense of how each person in the group feels about these concepts. Is there anything that anyone still doesn't completely understand? Is there anything that anyone maybe disputes or disagrees with? Is there anything that seemed particularly surprising or noteworthy to anyone?

3. Using a notebook, whiteboard, or scratch paper, list what you think are the most important ideas and concepts that you have learned so far. Aim to have at least 5 or 6 ideas written down. It is ok to have more than this.

4. As a group, try to determine how these ideas relate to the careers you intend to go into. Specifically…
   a. How might your daily activities in this future career be affected by these concepts?
   b. How might the decisions you make as part of this career be influenced by these ideas?
   c. How has your intended career area changed over time as a result of our understanding of these concepts? How might it continue to change in the future?

5. In the coming units, the focus will be on how to minimize the losses to biodiversity as a result of human activity. In other words, you will be learning about the causes of extinction and how the rate of extinctions can be reduced by adjusting how humans use natural resources.
   a. How do you think your career might *decrease* biodiversity and *increase* the likelihood of causing extinctions?
   b. How do you think your career could be changed in order to *increase* biodiversity and *decrease* the likelihood of causing extinctions?

Biodiversity & Ecosystem Services Indiv. Quiz

Name: _____ Hour_____ Date:_____ Score:_____ /___

Directions: This quiz should be completed on an individual basis. A 3x5 notecard with handwritten notes can be used on this quiz.

1. **A plant is sealed in a jar with an adequate amount of moisture and soil. Microorganisms such as bacteria and fungi are present in the soil at appropriate levels. The sealed jar with the plant, soil, and microorganisms is placed in a well-lit location. Is this an ecosystem?**
   a. No it is not – an ecosystem requires animals to function.
   b. Yes it is – an ecosystem is just a bunch of living organisms.
   c. No it is not – an ecosystem cannot function in an isolated environment.
   d. Yes it is – this has living species interacting with each other and with the nonliving substances inside the environment of this jar.

2. **Which of the items in this jar could be considered a <u>producer</u> that is able to create biomass from inorganic molecules?**
   a. The soil bacteria & fungi b. The plant c. The soil minerals d. None of the above e. All of these

3. **Which of the items in this jar could be considered a <u>consumer</u>, which is not able to create biomass from inorganic molecules and must consume other organisms?**
   a. The soil bacteria & fungi b. The plant c. The soil minerals d. None of the above e. All of these

4. **Which of the items in this jar could be considered a <u>non-living component</u>?**
   a. The soil bacteria & fungi b. The plant c. The soil minerals d. None of the above e. All of these

5. **Which of the following would decrease the biomass production in this jar?**
   a. Reducing the temperature b. Reducing the sunlight c. Reducing the moisture d. All of these

6. **Would it be feasible for the number of consumers to constantly be greater than the number of producers in an ecosystem?**
   a. Yes – because nutrients and energy cycle in an ecosystem, the amount of matter and energy in that ecosystem stay constant no matter how many producers or consumers exist.
   b. No – because only 10% of the matter and energy of a producer goes into the body of a consumer when eaten, so there must be many more producers than consumers.
   c. No – the amount of producers and consumers must be equal for an ecosystem to function.
   d. Yes – everything that is alive is carbon-based and carbon can neither be created nor destroyed.

7. **A lawn consists of a single species of grass as well as soil microorganisms and an occasional animal. A nearby prairie consists of multiple species of grass as well as various species of flowers in addition to animals and soil microorganisms. Which has greater biodiversity?**
   a. The lawn b. The prairie c. You cannot tell from this information alone.

8. **Would the lawn or the prairie have greater ecosystem resilience and function?**
   a. The lawn b. The prairie c. You cannot tell from this information alone.

9. **Would the lawn or the prairie have greater ability to provide ecosystem services?**
   a. The lawn b. The prairie c. You cannot tell from this information alone.

10. Which of the following best describes ecosystem resilience?

a. The benefits that an ecosystem can provide.
b. The diversity of living organisms in an environment.
c. The ability of a habitat or ecosystem to recover from a threat or disturbance.
d. The species that an ecosystem depends upon more so than other species.

11. Which of the following best describes ecosystem services?

a. The benefits that an ecosystem can provide.
b. The diversity of living organisms in an environment.
c. The ability of a habitat or ecosystem to recover from a threat or disturbance.
d. The species that an ecosystem depends upon more so than other species.

12. Which of the following best describes a keystone species?

a. The benefits that an ecosystem can provide.
b. The diversity of living organisms in an environment.
c. The ability of a habitat or ecosystem to recover from a threat or disturbance.
d. The species that an ecosystem depends upon more so than other species.

13. A corn field, a livestock ranch, and a suburban yard are all examples of human managed ecosystems. Which of the following best describes a human managed ecosystem?

a. Human managed ecosystems maximize biodiversity and ecosystem services so that humans can be provided with as many benefits as possible from an ecosystem.
b. Human managed ecosystems reduce biodiversity and focus on providing one kind of ecosystem service at the expense of other ecosystem services.
c. Human managed ecosystems would continue to function exactly the same with or without human intervention.

14. This is a stretch of DNA with the information needed to assemble a functional bodily molecule.

a. Protein b. Gene c. Natural Selection d. Mutation e. Evolution

15. This is the kind of molecule that does most of the work of the body and is responsible for most of the visible traits in an organism (such as eye color, size, etc.).

a. Protein b. Gene c. Natural Selection d. Mutation e. Evolution

16. This is the term for a change to DNA that may result in changes to an organism's traits. It is usually harmful but can sometimes result in a more beneficial trait.

a. Protein b. Gene c. Natural Selection d. Mutation e. Evolution

17. This is the process in which species with traits more appropriate and beneficial for their environment produce more offspring than those without those traits.

a. Protein b. Gene c. Natural Selection d. Mutation e. Evolution

18. This is the process in which an entire species changes over time (and possibly becomes a new species) due to beneficial changes to its DNA.

a. Protein b. Gene c. Natural Selection d. Mutation e. Evolution

19. Which of the following would NOT increase biodiversity?

a. Warmer, wetter environment b. Beneficial mutations c. Rapid environmental changes

20. The lower the biodiversity, the ___ the ecosystem services & the ___ the ecosystem resilience.

a. Greater, greater b. greater, lower c. lower, greater d. lower, lower

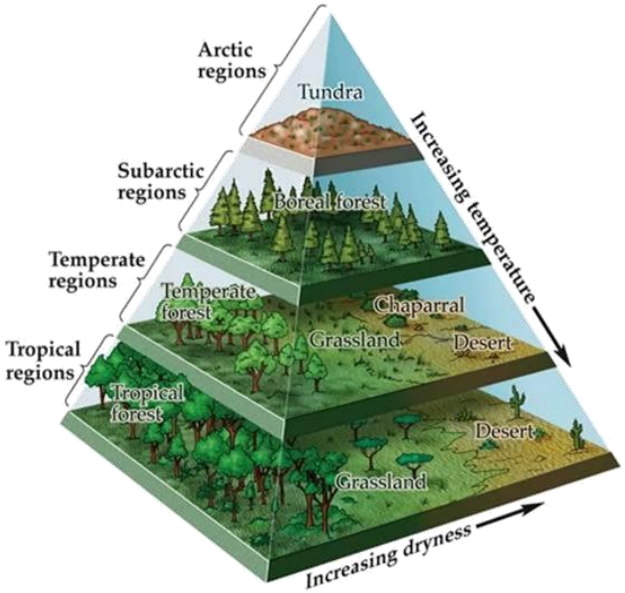
Biodiversity & Ecosystem Services Group Quiz

Names (F&L): _____

_____Hour_____Date:_____Score:_____/___

Directions: This quiz should be completed in your assigned groups. A 3x5 notecard with handwritten notes can be used on this quiz. Each person should take turns writing an answer. Those not writing should be actively working together to create their group's answer. Those who are not actively involved in answering every question may be asked to complete this quiz alone. Record the writer's name after each question.

1. **Some ecosystems (such as tropical rainforests) have immense amounts of biodiversity. These ecosystems tend to provide large amounts of ecosystem services and tend to be very resistant to disruptions and ecological threats. On the other hand, some ecosystems (such as cold desert regions such as the Antarctic and mountain tops) have very little biodiversity, provide very few ecosystem services, and are very susceptible to threats and disturbances. Using the image to the right, explain why this is the case. In your answer, be sure to address all of the following: *1) biomass production; 2) 10% rule; 3) producers & consumers.***



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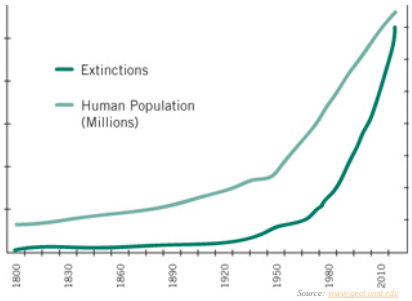
Writer's Name:

Currently the rate of extinction is roughly a thousand times faster than the normal rate of extinction. Species are now going extinct at a rate that is over 100 times faster than the rate at which the dinosaurs went extinct. Is this a problem for humans? How might this unprecedented rate of extinction affect the day-to-day lives of human beings? In your answer, include the following:
1) biodiversity; 2) ecosystem services; 3) types and examples of ecosystem services; 4) ecosystem resilience.



Writer's Name:

2. **Unusually warm springs in the Pacific Ocean have caused algal blooms that have poisoned sea otters, reducing their populations. Sea otters are a keystone species in these ecosystems. How might reduced sea otter populations affect the ocean ecosystems in which they are found? In your answer, define *keystone species* and summarize the importance of these kinds of species.**

Writer's Name:

3. **Human managed ecosystems differ from naturally occurring ecosystems in regards to their levels of biodiversity, the amount of ecosystem services provided, and the resilience of these ecosystems (i.e. their ability to function without human intervention). Briefly summarize how and why human managed ecosystems are different from naturally occurring ecosystems in regards to biodiversity, ecosystem services, and resilience. Use examples in your answer.**

Writer's Name:

4. **Where does biodiversity come from? How could more biodiversity be created? In your answer, be sure to include the following: 1) DNA; 2) genes; 3) proteins; 4) traits; 5) mutations; 6) natural selection; 7) evolution.**

Writer's Name:

Appendix: Setting up your Bioreactor Ecosystems

Introduction: Bioreactor Ecosystems use a very simple model of an ecosystem to help students understand the relationships between different species and nonliving resources that enable an ecosystem to function. In this case, brine shrimp (*Artermia salina*) and phytoplankton (*Tetraselmis sp.*) represent the two primary living species. The phytoplankton serve as the basis of the food chain as the photosynthesizing producers, while the brine shrimp are the consumers. Bacteria and other microbes naturally present in the water serve as the decomposers.

Materials: FACTS bioreactor (or a sealed 1000 ml Pyrex beaker or glass jar), artificial seawater (e.g. *Instant Ocean* and unchlorinated water such as spring water), phytoplankton solution (e.g. *Kent Phytoplankton*), brine shrimp (e.g. *Decapsulated Brine Shrimp Eggs*), pipette or syringe, stir plate or aerator.

Directions: To set up your ecosystem, start the following steps at least a couple of days prior to the class in which this set-up will be used.

1. Obtain a clean FACTS bioreactor (or sealable jar or beaker).
2. Add 400 ml of artificial seawater (this can be created using a product such as *Instant Ocean*; follow the instructions on the packet).
3. Add 1 ml of the phytoplankton to the bioreactor.
4. Add a small pinch of the brine shrimp cysts (eggs) to the bioreactor (if possible, add the eggs to an aerated flask of water a day or two earlier so that they are hatched and ready).
5. Place bioreactor in a sunny, well-lit location at constant room temperature (or place a fluorescent bulb near the bioreactors to provide a source of light).
6. Aeration and/or gentle stirring may be necessary initially to enable the ecosystem to get started.
7. Bioreactor ecosystems will need to be checked daily to ensure that they have sufficient levels of algae and shrimp. Add more algae if it cannot be detected. Add more shrimp cysts if none can be seen.

Amazon Prime Purchasing Keywords

- Artificial Seawater: “Instant Ocean Sea Salt for Marine Aquariums, Nitrate & Phosphate-Free”
- Phytoplankton: Kent Phytoplex Plankton
- Brine Shrimp: Decapsulated Brine Shrimp Eggs (Artemia Cysts) (2 oz.)