**Warm-up Activity**: Working with 2 – 3 students sitting near you, discuss your answers to the “Lesson 1 Flipped Learning Assignment”. Record the significant findings and conclusions from your conversation in the space below. Be prepared to share with the class.

Students should be provided with 5 minutes at the start of class to complete this activity. An additional 5 minutes can be used for some groups to share their answers. Routinely starting class with a review of the Flipped Learning Assignment incentivizes completion of pre-class work and holds students accountable. Because students have previously completed the work, they arrive in class with prepared answers that they can confidently share.

**Discussion Prompt #1**: What are the key concepts from the course that are referenced in the pre-class videos and readings? Brainstorm with 2 – 3 students near you. Describe these concepts in the space below.

Students may reference many concepts but should specifically refer to energy flow and nutrient cycling among other topics. Students may describe various biogeochemical cycles such as the nitrogen cycle and phosphorus cycles. Students may refer to various trophic interactions and roles, including predator-prey interactions, scavenging, and decomposition. Students may also refer to salmon as keystone species in their ecosystem. Broader themes of climate change, overfishing, and human-environment interactions are pertinent as well.

Allot 5 minutes for students to discuss and 10 minutes for students to share and clarification by the instructor.

**Discussion Prompt #2**: Review the figure below that shows some of the processes related to the nitrogen cycle on a scale of global change.



*Source: Understanding Global Change. University of California Museum of Paleontology. Available at* [*https://ugc.berkeley.edu/background-content/nitrogen/*](https://ugc.berkeley.edu/background-content/nitrogen/)

Where is nitrogen stored and where is it available for organisms to use?

Much nitrogen is stored in the atmosphere as atmospheric nitrogen, but this nitrogen is unavailable for organisms. However, fixation of nitrogen by bacteria in ocean and terrestrial ecosystems creates stores of nitrogen in the oceans and soil.

How do humans add nitrogen to the nitrogen cycle?

Nitrogen is added to the atmosphere through industrial activity and through agricultural activity, primarily as fertilizer.

What is the pathway for the addition of nitrogen into freshwater systems? What likely happens to nitrogen in freshwater systems?

The major source of nitrogen in freshwater systems appears to come from nitrogen on land that is transported via erosion. This nitrogen can be accumulated by freshwater organisms, but it will also be transported to the ocean.

Modify the figure so that it includes the role of Pacific salmon in the nitrogen cycle and any other associated interactions.

Students should draw the nutrient transport of nitrogen from the ocean to headwaters of the river and indicate how nitrogen can be dispersed to the land surrounding the stream. Allot 5 minutes for students to answer and 5 minutes for the instructor to review the answers.

**Concept Mapping Activity**: Thus far, this activity has clarified how salmon contribute to the flow of energy and nutrients into freshwater streams and the surrounding terrestrial ecosystems. The assigned videos and readings completed before class discussed how salmon interact with other organisms in the ecosystem. Working in groups of 2 – 3, your assignment is to illustrate these interactions and describe them through the construction of a concept map. Each group will turn in this concept map at the end of class for a grade. Use all available notes and resources to assist you.

**Adult Pacific Salmon in Ocean**

Modification: This activity can be modified as a Gallery Walk activity. If board space is available throughout the classroom, student groups can be assigned board space to construct the concept map. Alternatively, large adhesive sheets of paper or poster board can be provided. Students can be given approximately 10 minutes to develop the map. Then a 5 – 10-minute review period can occur in which students roam around the classroom reviewing concept maps developed by other students. They can use sticky notes to leave comments on maps relating to missing interactions and connections. Students then return to their own map and review the comments and spend the remaining class time revising and adding to their concept map. Students can submit their concept maps by taking a picture and uploading to the course LMS or emailing to the instructor.

Extension Activity: Identify a terrestrial migratory species. Describe its migration and research the influence of this migration on its ecosystem. Discuss any human-caused disruptions to its migration and the associated impact on the ecosystem. This can be used as a post-class assignment in which students write a short summary or produce a diagram.

Alternatively, students can create a prompt in ChatGPT to generate a response from this activity. Students must then translate this response into a diagram showing the migratory journey of the species, its influence on ecosystems along the way, and where human disruptions occur.

A typical response from ChatGPT that could be converted to a diagram is included below:

One example of a terrestrial migratory species is the wildebeest, specifically the blue wildebeest found in the Serengeti ecosystem of East Africa. These animals undertake one of the most iconic migrations on Earth, known as the Great Wildebeest Migration.

The migration typically covers a distance of around 800 kilometers (500 miles) annually, looping through the Serengeti National Park in Tanzania and the Maasai Mara National Reserve in Kenya. The migration is primarily driven by the search for greener pastures and water sources. It's a cyclical journey, influenced by the changing seasons and the availability of food and water.

During the dry season (typically from June to October), the wildebeest gather in massive herds in the southern Serengeti and northern Ngorongoro Conservation Area, where grazing is still available. As the dry season progresses and water sources diminish, the herds start moving northwestward toward the Grumeti River and eventually cross into the Maasai Mara in search of fresh grazing grounds. This journey is fraught with dangers, including predators like lions, crocodiles, and hyenas.

The wildebeest migration has profound effects on the Serengeti-Mara ecosystem. It is a key driver of nutrient cycling as their movements distribute nutrients through their dung, enriching the soil and supporting plant growth. Additionally, their grazing behavior helps maintain the grasslands, preventing shrub encroachment and promoting biodiversity. Wildebeest also serve as a vital food source for predators, sustaining populations of lions, cheetahs, and other carnivores.

Human activities have increasingly disrupted this natural migration pattern. Encroachment of human settlements, agriculture, and infrastructure development has fragmented the landscape, obstructing traditional migration routes. Fences, roads, and settlements can block the wildebeests' path, forcing them to deviate from their natural routes or leading to fatal encounters with vehicles.

Overgrazing in certain areas due to livestock farming can also reduce the availability of suitable grazing grounds for the wildebeest, further disrupting their migration patterns. Climate change, with its unpredictable weather patterns and altered rainfall regimes, poses additional challenges by affecting the availability of water and vegetation along the migration route.

These disruptions not only threaten the survival of the wildebeest population but also have cascading effects on the entire ecosystem. Reduced nutrient cycling, changes in vegetation structure, and altered predator-prey dynamics can destabilize the delicate balance of the Serengeti-Mara ecosystem, leading to declines in biodiversity and ecosystem health. Therefore, conserving and restoring the wildebeest migration routes are essential for maintaining the ecological integrity of this iconic landscape.