24.11.15: biodiversity lab

Biodiversity has two elements:

- Species richness: the number of different species in an ecosystem
- Species evenness: the relative proportion of individuals within the different species in a given area

We'll be using colored goldfish (species) to demonstrate this, in several cases:

1. totally random distribution, calculate H (Shannon's index)
2. uneven distribution: major species takes over, calculate H
3. limited diversity example: few species, calculate H
4. species richness, many species, even distribution, calculate H

We'll be using a formula that looks scary, but is not really, called Shannon's index:

DO THE MATH Measuring Species Diversity

Preparing for the AP® Exam

Environmental scientists are often interested in evaluating both species richness and species evenness, so they have come up with indices of species diversity that take both measures into account. One commonly used index is Shannon's index of diversity. To calculate this index, we must know the total number of species in a community (n) and, for each species, the proportion of the individuals in the community that represent that species (p_i). Once we have this information, we can calculate Shannon's index (H) by taking the product of each proportion (p_i) and its natural logarithm [ln (p_i)] and then summing these products, as indicated by the summation symbol ($\sum$):

$$H = -\sum_{i=1}^{n} p_i \ln (p_i)$$

The minus sign makes the index a positive number. Higher values of H indicate higher diversity.

Imagine a community of 100 individuals that are evenly divided among four species, so that the proportions (p_i) of the species all equal 0.25. We can calculate Shannon's index as follows:

$$H = -[(0.25 \times \ln 0.25) + (0.25 \times \ln 0.25) + (0.25 \times \ln 0.25) + (0.25 \times \ln 0.25)]$$
$$H = -[(-0.35) + (-0.35) + (-0.35) + (-0.35)]$$
$$H = 1.40$$

Now imagine another community of 100 individuals that also contains four species, but in which one species is represented by 94 individuals and the other three species are each represented by 2 individuals. We can calculate Shannon's index to see how this difference in species evenness affects the value of the index:

$$H = -[(0.94 \times \ln 0.94) + (0.02 \times \ln 0.02) + (0.02 \times \ln 0.02) + (0.02 \times \ln 0.02)]$$
$$H = -[(-0.06) + (-0.08) + (-0.08) + (-0.08)]$$
$$H = 0.30$$

Because this value of H is lower than the value we calculated for the first community, we can conclude that the second community has lower diversity. Note that the total number of individuals does not affect Shannon's index of diversity; only the number of species and the proportion of individuals within each species matter.

YOUR TURN Imagine a third community of 100 individuals in which those individuals are distributed evenly among all the species, but there are only two species, not four. Calculate Shannon's index to see how this difference in species richness affects the value of the index.

- In each case, record the number of each species (color of goldfish), H for each, and take a photo of each bowl (ecosystem).
- Low numbers are like 1.5, high numbers are 4.5
- Make sure to bring YOUR notes on YOUR data to class next for a quiz.

Lab: Calculating Shannon's index, using baked goldfish (the cheddar kind, not the ones that stink)

1. wash your hands
2. pour out a random number of different colored goldfish on your plate (your "pond")
3. determine the number of distinct populations by color, using chopsticks, if available
4. determine the proportion for each population (e.g. 5 red ones out of 20 total would be 5/20 or 0.25)
5. calculate Shannon's index (H) for this "pond"
6. repeat the experiment with a very low biodiversity, calculate H
7. repeat with a very high biodiversity, calculate H
8. record all of your data on your notes (not shared notes) for next class

9. eat the contents of your "pond", representing a catastrophic event where the poor goldfish have poor resistance...

Questions: email your answers before next class

1. what is the value of biodiversity in any community?
2. what are the benefits and drawbacks of a low biodiversity?
3. how does this play into competition?
4. what is the difference between species richness and species evenness?
5. what is the impact of this on a human population, e.g. the census?
6. if you have 10 each of the six colors of M&M candies, what is the H value for this?
7. You then eat some, leaving 10 brown, and 2 of each of the rest, what is H now?
8. which of these colors would likely be an invasive species in a simulation?
9. How does agriculture affect biodiversity? Discuss the impacts of monoculture farming compared to polyculture practices.
10. Describe the primary threats to marine biodiversity, including overfishing and coral reef degradation.

Notes on Shannon's index:

Shannon Diversity: It might sound complex, but at its core, it quantifies **ecological complexity**, using an index for measuring the variety and abundance of life in a given area.

Here's the key link to biodiversity: Shannon Index reflects how much we can *predict* about each species within a community based on observing others:

1. **Diversity Indices:** The index assigns scores to communities, reflecting their diversity levels. A higher score means greater diversity!
2. **Species Abundance & evenness:** The formula considers both the number of different species (species richness) and how equally abundant they are in terms of relative population sizes (evenness).

Why does this matter? Understanding biodiversity is crucial for these reasons: :

- **Ecosystem Stability:** High diversity often leads to more resilient ecosystems that can better withstand environmental changes.
- **Conservation Efforts:** Identifying areas with high biodiversity allows targeted conservation efforts, ensuring we protect the most valuable species and habitats.
- **Predictive Models:** The index helps researchers predict how a change in one species might impact another (e.g., top-down or bottom-up effects) within a community.

How it works (simplified): Imagine an area with:

- Lots of different plant and animal species, like rainforests.
- Some plants are very common, some rare, making for uneven distribution in the ecosystem

The Shannon Index would consider these factors to calculate its diversity score based on how much we can predict about each unique life form within that community given what's already known.

Example:

- A diverse forest with numerous tree species (high richness) and a relatively even population of those trees across the area (evenness) will likely have a higher Shannon Index value compared to an area dominated by just one or two dominant species, indicating less diversity.

Keep in mind: The Shannon index is not perfect. It doesn't capture everything about biodiversity; it focuses on predicting the overall 'information content' of the system based on observed species variation within a specific community

In summary: The Shannon Index offers a valuable tool for biologists and ecologists to quantify ecological diversity, which helps in understanding how nature functions as a whole.

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