Chapter 47 Project

A Close Look at Biodiversity

Project Goal + Timeline

In this project, you'll investigate biodiversity at the biochemical level. You'll use an online database to explore diversity in enzymes and metabolic reactions among different species. You'll consider how metabolic diversity relates to ecosystem functioning, and you'll predict the impacts of the loss of certain enzymes on ecosystem health and stability. This project should take between one and two hours to complete.

Directions

The presence of a diverse array of species is important to ecosystem health and stability, not to mention the survival of our own species. While diversity can be assessed through many parameters, you will complete this project by considering biochemical diversity in an ecosystem. You will survey different metabolic pathways and the enzymes they contain to gain insight on their distribution across different species. Some enzymes are widely conserved, while others exist only in select species.

To investigate this diversity, you will utilize the KEGG (Kyoto Encyclopedia of Genes and Genomes) database. This database links metabolic activity and enzymes in an organism to the gene(s) that encode(s) them. There are many ways to explore this resource, but the recommended approach is as follows:

1. Go to the KEGG PATHWAY Database (hawkes.biz/KEGG).
2. Under "Pathway Maps," select "Metabolism."
3. Investigate different metabolic pathways by clicking the link for each. After selecting the pathway, you will see a map. In the map, molecules are indicated by their name and a small circle, reactions are indicated by arrows, and enzymes that catalyze the reactions are indicated by an enzyme classifier (EC) number, such as 1.2.7.11.
4. Select one of the enzymes in the pathway. This will bring you to a table that describes the enzyme in detail, including the enzyme's name, all the pathways in which it is used, and all the genes that encode the enzyme. The genes encoding the enzyme are typically listed in the seventh row of the table.
5. Investigate the number, type, and diversity of species that have the particular enzyme. There are two ways to conduct this exploration:
    - Select the "UniProt" button at the bottom of the "Genes" section of the table. This will bring you to a list of genes that produce enzymes similar to or the same as the one you are investigating. Perform a text search (using CTRL+F on your keyboard) for the exact name of the enzyme to get a quick count of the number of instances of that exact enzyme on the page. This total will give you an indication of how widespread the enzyme is. For each matching entry, you can click on the name of the gene in the entry to locate the name of the species with the enzyme.
    - You could also select the "Taxonomy" button at the bottom of the "Genes" section of the table. This view shows the relationships among organisms that produce the enzyme, which helps to visualize whether the enzyme is present in many related species or widely dispersed across the tree of life.

Your goal is to survey different types of reactions and pathways to identify three different enzymes. You should find examples of enzymes to fit each of the following:

- **A common enzyme**: an enzyme/enzyme-catalyzed reaction present across many different diverse species
- **A rare enzyme**: an enzyme/enzyme-catalyzed reaction present in approximately 5 to 10 species
- **A unique enzyme**: an enzyme/enzyme-catalyzed reaction present in only 1 to 3 species

Hint: To locate rare and unique reactions, try exploring pathways listed under the sections "1.10 Biosynthesis of other secondary metabolites" or "1.11 Xenobiotics biodegradation and metabolism."

Complete Table 1 for the three enzymes you identified. It may be helpful to consult additional resources from the internet to complete the table.

TABLE 1: Common, Rare, and Unique Enzymes Identified through KEGG

	Common Enzyme	Rare Enzyme	Unique Enzyme
Name of enzyme			
Gene(s) that encodes enzyme			
Number of species in which the enzyme is found			
Description of metabolic reaction in which enzyme participates			
White removed (remaining)			

Perform some additional research to answer the following questions concerning the **rare** and **unique** enzymes you identified in Table 1.

1. Describe one species with the rare enzyme and one species with the unique enzyme. In what ecosystem(s) is each of these species found?
2. How does each enzyme, and the metabolic reaction in which it participates, contribute to the survival of each organism/species identified in Question 1?
3. Do either of the enzymes and their associated metabolic reactions have any relevance to ecosystem health or human health? Explain.
4. Are any of the species identified in Question 1 endangered? Is the ecosystem in which they live threatened?
5. Select one of the species (endangered or not). How might human activities (either direct or indirect) affect its survival in the future?
6. For the species selected in Question 5, how would the loss of the species' enzyme and associated metabolic reaction from the ecosystem affect ecosystem health, functioning, and overall stability?
7. How does the information in the KEGG database highlight the importance of preserving biodiversity?
8. How could the information in the KEGG database be used to help preserve biodiversity?

Project Materials

- Project worksheet and a pen
- Computer with internet access
- Access to the KEGG database (hawkes.biz/KEGG)

Student Checklist

- ☐ Complete Table 1
- ☐ Complete all questions