WATER IS LIFE: Winogradsky Column

Grade 6th

Vocabulary

microorganisms
domains
Bacteria
Archaea
Eukarya
unicellular
prokaryotic
eukaryotic
kingdom
closed system
Winogradsky Column
aerobic
anaerobic
microbes

Activity Overview

In this activity, students will understand the three taxonomic domains by creating a Winogradsky column using El Paso soil.

TEKS Alignment

6.12 A. The student is expected to understand that all organisms are composed of one or more cells.

6.12 B. The student is expected to recognize that the presence of a nucleus is a key factor used to determine whether a cell is prokaryotic or eukaryotic.

6.12 C. The student is expected to recognize that the broadest taxonomic classification of living organisms is divided into currently recognized domains.

Materials

Per Group:

- 4 Plastic water bottles (tall and narrow with a smooth inside)
- Plastic gloves
- Scissors
- Marker
- Ruler
- Trowel or shovel
- Two buckets
- Newspaper or plain paper (shredded)
- A boiled egg
- Two smaller bowls
- Two large mixing bowls
- Measuring cup or scoop
- Wide stick
- Measuring spoon
- A warm area to place your Columns
- Plastic wrap
- Plastic trash bags or grocery bags
- Four rubber bands
- Cardboard box or brown paper bag

Per Student:

- *El Paso Water Chronicle:* Issue 2
- Procedures and student worksheets to Build Your Own Winogradsky Column

THE SCIENCE BEHIND IT: Taxonomic Domains

6.12 A Commonalities of Life: All life is comprised of cells
Cells are what distinguish all non-living things from living things. Whether we look at single-celled bacteria or Archaea or a tree or elephant, if tissue is taken and placed under a microscope, we see that all living things are comprised of cells. How these cells are comprised in life and the qualities of living things from one species to another are classified in a science called taxonomy.

In this lab students will investigate organisms from two of the three domains of taxonomy, the Bacteria and Archaea domains. Both domains describe single-celled organisms (unicellular), and these organisms also have no nucleus (prokaryotic).

6.12 B Recognizing the presence of a nucleus: Eukarya, which represents the third domain are organisms that have cells that do contain a nucleus, (eukaryotic). The nucleus of a cell acts as a central system (like a brain) that tells the parts of the cell what to do. There are single-celled eukaryotic organisms, and their kingdom is called Protists. Like bacteria and archaea, they are microscopic. Protists are described in the "Build Your Own Hueco" activity in Issue 1 of the El Paso Water Chronicles. Eukarya can be unicellular or multi-cellular organisms that include plants, animals and fungi. All are comprised of cells with a nucleus and therefore fall under the domain of Eukarya.

6.12 C Currently recognized domains: It wasn't until 1990 that Dr. Carl Woese and his colleagues understood that there should be three rather than two taxonomic domains. Prior to that, there were only two: Bacteria and Eukarya. Bacteria was divided into two kingdoms: Bacteria and Archaea, and these single-celled microbes were distinguished by cell structure and behavior. Eukarya was distinctly different from Bacteria, but scientists were not able to tell how much different until the advent of DNA studies. Archaea were once thought to be rare, but with the discovery of Archaea in extreme environments, such as volcanic vents, it was found that Archaea are present in extreme environments once thought to be lifeless. Now, we know Archaea actually represent 20% of all living organisms on Earth and that they have a very different cell construction and DNA replication than bacteria. It is now commonly accepted by scientists that Archaea should be its own domain.

Teacher Overview

This exploration has students create a Winogradsky Column. Winogradsky Columns are used by microbiologists to identify which microbes are present in soil samples. The columns demonstrate that different kinds of microbes from anaerobic (not needing oxygen to survive) to aerobic (needing oxygen to survive), can inhabit a small environment, that water is an essential component of life, and that many different types of organisms can be found in dirt. Students typically are not aware that bacteria are found in the environment around them, including the dirt all around us.

Students can create their own Winogradsky column by wetting a sample of dirt, adding a carbon and sulfur source and simply letting the column grow for a few weeks. At the end of a few weeks, students should notice definitive “life zones” where the bacteria in each layer have distinct characteristics, most notably color. The different colors indicate the different types of bacterial growth and what each type use for food.

The type of organisms in the columns might include: clostridium desulfovibrio, chlorobium, chromatium, rhodomicrobium, beggiatoa, as well as many other species of bacteria, cyanobacteria, and algae. The success of each student’s columns may differ depending on variables, including temperature, exposure to light, type of soil collected, time of year, and of course the type of additive (carbon, sulfur or both) placed in the samples.

In the Winogradsky environment, organisms at the top of the column are exposed to oxygen, while those at the bottom quickly deplete their oxygen supply and “switch” to other sources. The colored organisms essentially are an indicator of how much oxygen is readily available to organisms. Further down the column, there is less oxygen and change based on which nutrients are consumed.

In this exploration, students create four separate columns based on the type of nutrient added: a control with no nutrient added, a column with newspaper (carbon) as the nutrient source, a column with sulfur as a nutrient source (egg) and a column with both carbon and sulfur. Successful Winogradsky Columns can take anywhere from 2 to 4 weeks to grow, so students must be patient when expecting results. No two similar columns will look exactly the same, but there should be some common colors emerge often with algae living at the top of the column.

ENGAGE: El Paso Water Chronicles Issue 2: Testing the El Paso-Soil For Life

Students will read the El Paso Water Chronicle and discuss the taxonomy of organisms and Winogradsky columns.

EXPLORE: Build Your Own Winogradsky Columns

Students will need the "Build Your Own Winogradsky Column" Procedure worksheet.

Whole Class: Students will read and discuss the procedure that includes a chart that allows students to identify the bacteria or archaea that may be growing in the column. The teachers may want to discuss the colors to look for, position on the column they would appear and behavior, such as bubbling. This is a long-term observational study that will take place over many weeks. It is important to note that the system is a closed system which means that the plastic wrap stay on the bottles over time. If using jars for the columns, keep the lids loosely placed on the jars allowing gases produced by the column to escape. You may want to store these columns in a safe place in the lab to prevent spillage.

Purpose: To build a model of an ecosystem that will host both bacteria and archaea organisms, understand that ecosystems thrive in a variety of harsh conditions and that living organisms can live in a variety of environments. Water is an important part of all ecosystems.

Materials

- Plastic gloves
- Scissors
- Marker
- Ruler
- Two smaller bowls
- Measuring cup or scoop
- Measuring spoon
- Four rubber bands
- Newspaper or plain paper (shredded)
- Soil from the outdoors, (quicker results would be from a ponding area, but a garden will do)
- 4 Plastic water bottles (tall and narrow with a smooth inside)
- A warm area to place your Columns
- Plastic trash bags or grocery bags
- Cardboard box or brown paper bag
- Camera (optional)
- Plastic wrap
- Trowel or shovel
- Two buckets
- A boiled egg
- Two large mixing bowls
- Wide stick

Answers to the Microbe Farms, Just Add Water Word Puzzle

1. Microorganisms
2. Three domains
3. Bacteria
4. Unicellular
5. Prokaryote
6. Archaea
7. Eukaryotic
8. Kingdom
9. Closed system
10. Winogradsky Column

Procedure

1. Carefully cut off the tops of your bottles using scissors. Individually label the bottles Control, Carbon, Sulfur, and Carbon + Sulfur.
2. In a bucket, collect enough mud from a ponding area to fill all four of your bottles plus a little extra. If you are using 1-liter bottles, collect 5 liters of mud. Try to avoid large pieces of material such as twigs or leaves or roots. The mud should be saturated with water. You will need enough mud to fill each of your bottles about 80% full.
3. Collect enough water from a pond to cover your mud. Water that has been left outside for a night will also work. Keep the water separate for now.
4. In the first mixing bowl, transfer enough mud to fill your bottle full twice to the mixing bowl, removing any twigs, leaves or rocks. Break apart any large clumps of dirt. Add water until the mixture is the consistency of a fruit smoothie.
5. Transfer enough mud from the bowl to fill your Control bottle 80% full. Tap the bottom of the bottle against a solid surface to remove air pockets. You may use the wide stick to push down the dirt, but do not pack it tightly.
6. Back in the first mixing bowl, repeat Step 4, but this time add a sheet of shredded newspaper or plain paper. Mix the paper into the mud until it is thoroughly mixed in.
7. Repeat step 5, but to the bottle labelled “Carbon.”
8. In the second mixing bowl, repeat Step 4, but this time add your hard-boiled egg. Mix thoroughly.
9. Repeat Step 5, but to the bottle labelled “Sulfur”
10. Add the remaining Carbon and Sulfur mud together and mix.
11. Repeat Step 5, but to the remaining bottle “Carbon + Sulfur”
12. Pour the remaining water into each bottle until each bottle is about 90% full.
13. Cover each bottle tightly with plastic wrap.
14. Set each bottle in a warm environment near a window, but not in direct sunlight. Let the water settle.

Observations

1. Using the Winogradsky “Design an Observation Table” Worksheet, design a table to record your observations of your Winogradsky Columns. Students may want to include: colored drawings or pictures of the columns, colors observed, position in the column that it was observed, guesses as to which Bacteria or Archaea may be growing in the column, and justifications as to why this organism may be archaea or Bacteria based on the information table given on page 1.
2. Students will record what the Winogradsky column looks like every 4 days for 5 weeks. Record any changes in colors and mark where each different color shows up in the column. Some of the colors might be very subtle, so look closely.

*Optional: Students could take pictures every 4 days for 4 weeks of the column and to see how the colors change. Place the pictures in the observation journal or worksheet.

Example of a Completed Observation Table Design: (answers may vary)

Design a Observation Table

Using this Winogradsky Worksheet, design a table to record your observations of your Winogradsky Columns. You may want to include: colored drawings or pictures of the columns, colors observed, position in the column that it was observed, guesses as to which bacteria or archaea maybe growing in the column, and justifications as to why you believe that this organism may be archaea or bacteria based on the information table given on page 1.

Day 1	Description of Column	Observation
Drawing of Column	Top	
	Middle	
	Bottom	
Day 4	**Description of Column**	**Observation**
Drawing of Column	Top	
	Middle	
	Bottom	
Day 8	**Description of Column**	**Observation**
Drawing of Column	Top	
	Middle	
	Bottom	

Students will research El Paso desert organisms using the “Ernie’s Way to Think About How to Classify Organisms” Worksheet.

Whole Class: Students will read and discuss the way Ernie thinks of classification by relating ideas behind classification and identifying where a person lives. The reading discusses Scientist Carl Linneus and refers to how the Latin language is used to describe organisms. This makes a great discussion for EL Spanish language speakers to use their knowledge of Latin roots to decipher the names assigned to organisms in taxonomy.

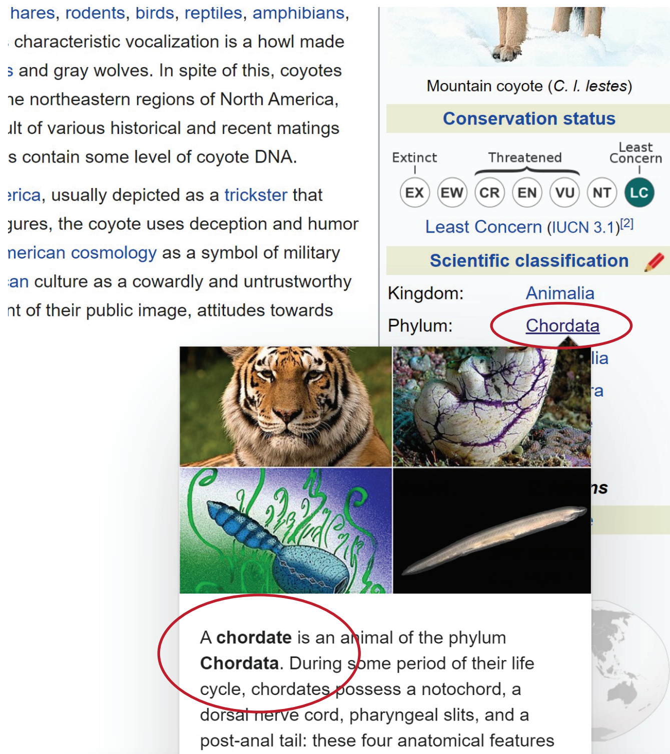
During this activity students will do some light research and choose one organism from the list of desert organisms provided to decipher the meaning of the organism’s taxonomic name. An example of how to do this is provided by Ernie on page one of the activiity where Ernie deciphers the taxonomy of the Coyote. (shown below)

Ernie created this chart to classify an El Paso desert animal: Canis Latrans

Classification	Organism	Meaning
Domain	Eukarya	Organisms that have cells with a nucleus
Kingdom	Animalia	Multicellular organisms that breathe oxygen and reproduce sexually
Phylum	Chardata	Animals that have bilateral symmetry and have a dorsal nerve chord
Class	Mammalia	Animals that have live births, have hair or fur and feed their young with milk from mammaries
Order	Carnivara	Animals that eat the flesh of other animals
Family	Canidae	Of the dog family
Genus	Canis	Of the group: Wolves, Dogs, Coyotes and Jackals
Species	Latrans	“bark or roaring” dog (probably from its howl)

This animal’s local name is taken from the Aztec word coyotl, which means “Trickster”
Can you guess t his animals name? ___________________________________

Students can research this information using Wikipedia. If the student looks up an organism of interest that is on the list, the right-hand side of the Wikipedia page will provide the scientific name of the organism. If the student hovers their mouse over the classification, such as phylum or genus, the Wikipedia page will provide a definition for the organism’s name. Here is an example from the Coyote example:



Wikipedia Research Example

Students will hover over the classification name in order to get the meaning of that part of the scientific name.

Students will research one organism from each of the 6 kingdoms represented in the 3 Domains for classification: Animals, Plants, Fungi, Protists, Bacteria and Archaea.

Once the students are done with their research, they can share their findings with the class.

The students will provide a sketch of the organism as part of their research.

Management: If students seem to be gravitating toward one particular organism, the teacher can place the students in groups and have each member of the group research a different organism and discuss their findings with the group after the activity is completed.

ELABORATE: Results of the Winogradsky Observation

The Winogradsky observation is a long-term observational study. After 5 weeks of observations, the students can conclude the study by reporting out their results:

Results

1. In previous explorations (Water is Life I) you looked for signs of life in your dirt sample after water was added. These signs included movement and bubbles, as well. What signs of life did you find in your Winogradsky Column?

2. Did your column have the same results as others?

3. How did the colors change based on the nutrient type?

4. Did colors change over time? How?

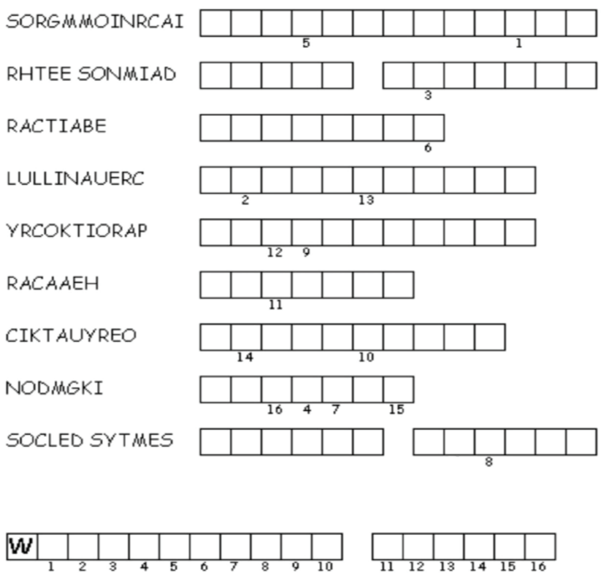
5. List some of the variables you could change in this exploration.

Extensions

- Do the same exploration, but change the source of the mud.
- Do the same experiment but change the amount of light / temperature/ water.

WORD PUZZLE: MICROBE FARMS, JUST ADD WATER!

by Carmen



Unscramble the vocabulary words and use the numbered boxes to solve the puzzle

COMIC By Ernie

EL PASO WATER CHRONICLES

Water and Science News from El Paso

PHOTO COURTESY OF TEXAS PARKS AND WILDLIFE

IN THIS ISSUE

TESTING THE EL PASO SOIL FOR LIFE

By TecH$_2$0

We know that water is needed for all of the organisms that we can see, but what about those living things that we cannot see? Even though we live in a desert, we still see pill bugs, earthworms, grubs, and beetles in our El Paso dirt. These animals are known as decomposers. As the name suggests, decomposers break down and eat smaller things that live in dirt, like algae, fungi, and bacteria. If they are living in our El Paso soil, what on "Earth" is keeping animals like these alive? While not readily visible, our El Paso soil has a world of organisms that form food webs. In our dirt, mud, and gardens, bugs and worms feast on organisms that feed on even smaller microorganisms, also known as microbes, too small to be seen by the naked eye. These microorganisms then eat smaller and smaller microorganisms, until the smallest living things have only chemicals like sulfur, carbon, and nitrogen left to eat.

When scientists gather soil samples to test for the presence of microorganisms, they run into a problem. Microorganisms are so small and so far apart from each other, that it is nearly impossible for scientists to determine what type of living things are present in the sample. It wasn't until about 100 years ago that scientists figured out a way to test the soil for these microbes.

In order to do so, microbiologists had to create microbe farms! In fact, kids can create their own microbe farm to test the soil. Before starting a microbe farm, we will need to know how to identify our microbial crops. To do this, we will take a short detour to talk about how scientists classify organisms.

Classifying Organisms: Using Domains

There are many kinds of microorganisms that live in the ground just beneath your feet. Scientists classify microorganisms into 3 domains (or categories): Archaea, Bacteria and Eukarya. Organisms belonging in the Archaea and Bacteria domains are microbial and have only been discovered since the invention of the microscope. All other living things, including plants and animals, fall under the domain of Eukarya. As we have learned about living things, we know that all living things have basic needs and are comprised of cells. How their cells are structured, however, are what separates these living things into the three domains.

ARCHAEA

The first domain that we will learn about is Archaea. Archaea are believed to be the first type of life that ever existed on Earth. Though all of the organisms found in the domains of Bacteria and Eukarya have the basic needs of water and food, most Archaea do not need oxygen to survive and have probably existed before the Earth had formed its current oxygen-rich atmosphere. Archaea are unicellular, meaning they only consist of a single simple cell. Archaea cells are so simple that they don't even have a nucleus like the more complex cells of plants, animals, and fungi, which are all found in the Eukarya domain. Scientists call cells that do not contain a nucleus prokaryotic- "pro" meaning before and "karyo" meaning kernel (nucleus). Archaea have been detected in harsh conditions and at extreme temperatures. Because most archaea can survive extreme conditions, it is speculated that archaea could likely be found living outside of planet Earth, in places in our Solar System that contain icy oceans of water, such as Jupiter's moon, Europa, or Saturn's moon, Titan.

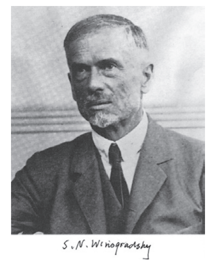
BACTERIA

The Bacteria domain is the most successful group of organisms known, growing in almost any type of environment, ranging from thermal hot springs to thunderclouds. It was once thought that archaea and bacteria belonged in the same domain, originally being separated into different kingdoms. Only recently were these microbes cast into separate domains. All bacteria, like archaea, are unicellular, meaning they too only consist of a single cell and they are both prokaryotic or lacking a nucleus. Both archaea and bacteria can be aerobic (oxygen-dependent) or anaerobic (oxygen-independent), meaning that they both have species living in conditions with or without oxygen. The difference between archaea and bacteria is that bacteria have a different cell structure and DNA replication process than archaea.

The last domain is Eukarya. The Eukarya domain hosts microorganisms, plants, fungi, and animals. What separates Eukarya from the other two domains is that Eukarya organisms have cells WITH a nucleus, "eu" meaning good, and "karyo" meaning kernel (nucleus). The nucleus of a cell is like a brain, in that it controls the activities that a cell is able to do. Under the Domain Eukarya, scientists have classified four main kingdoms: Plants, Animals, Fungi and Protists. While we can easily observe plants, animals, and some fungi, the protist kingdom is a kingdom of microorganisms that can only be seen with the help of a microscope. In our last chronicle, we described many protists that can be grown in the huecos of Hueco Tanks State Park, including species that are found only there at the state park. Can you name some of those microorganisms that we studied?

EUKARYA

Microbe Farms, Just Add Water!



All soils in El Paso contain microorganisms, but they are difficult to see. The Winogradsky Column, named after a Russian scientist, Nikolaievich Winogradsky, who invented it, makes viewing these microbes a lot easier. This device is still used today by scientists to see what microorganisms exist in a sample of soil. Just like a farmer, if we want to grow a lot of one type of food, we grow it as a crop in a farm. By creating a Winogradsky column, we will be able to grow and "see" these tiny microbes that aren't normally visible. "Farming" large amounts of these microbes in spots large enough to see will make them visible. How do we grow a large amount of microbes? We will do this by providing some basic needs: food and most importantly, water. To grow the microbes, scientists will mix a sample of soil with water, along with a type of food they are known to eat, such as sulfur or carbon. The soil mixture is then placed in a clear cylinder container, often referred to as a column, and is left in a closed system for a period of weeks to see what grows. The column resembles a terrarium for bacteria. Imagine that you are growing billions of crops, in fact, 1 billion bacteria are known to fit on the head of a pin. It takes billions upon billions of bacteria cells to make a colony large enough to be seen with the naked eye. The colors produced and where they appear will help to identify the strain of bacteria or archaea based on the presence or absence of oxygen. Figure A shows an example of the Winogradsky column.

Since Winogradsky columns are closed systems, they can be maintained for years and even decades! Some of the oldest Winogradsky columns still growing microbial colonies today were actually created in the 1940s. They also can become so colorful that people have actually grown them as art to decorate a house, just like an aquarium or terrarium. We have provided a Winogradsky Column procedure so that you can create your own Winogradsky column from El Paso soil samples!

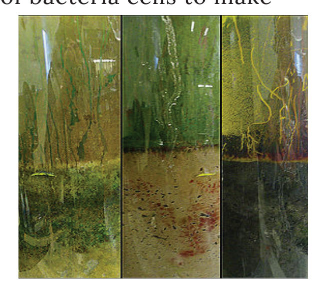
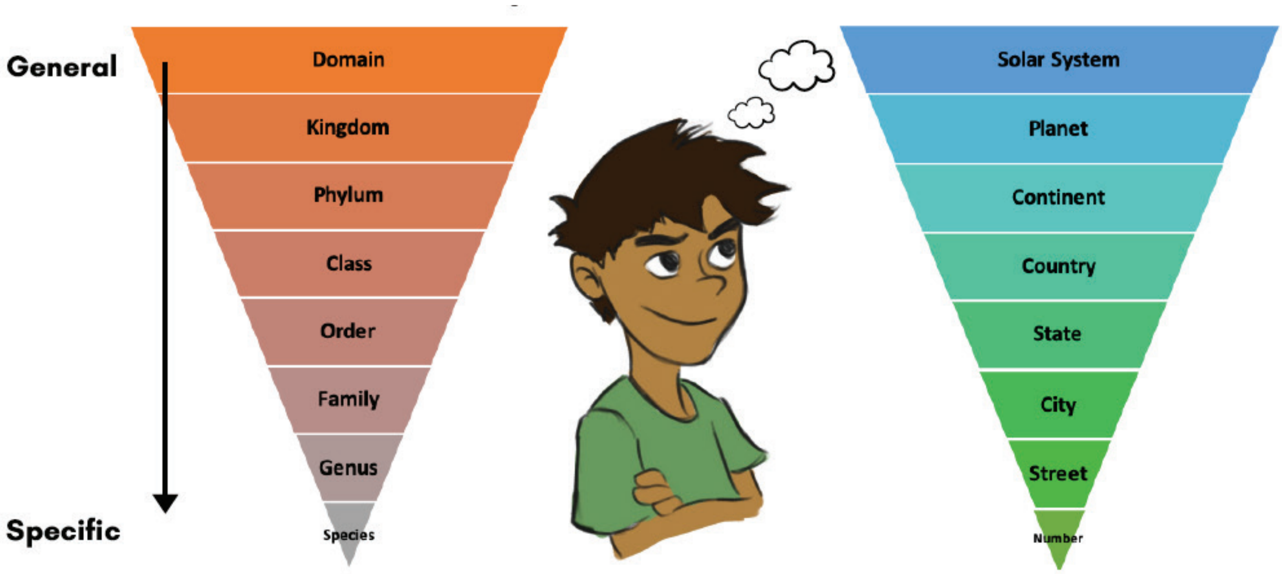


PHOTO COURTESY OF TEXAS PARKS AND WILDLIFE

Ernie's Way to Think About How to Classify Organisms

Taxonomy is the science of classifying and naming living organisms. How scientists classify organisms may seem difficult, but it's not. All you need to know is your address!

Here is how a scientist classifies organisms: Here is how Ernie thinks about classification



The more specific a scientist describes an organism, the better the identification we have of that organism, much like the more specific we get with your location, the easier it is to find where you live. Scientist Carl Linneaus, the father of taxonomy used the Latin language to describe organisms. Since Latin is a language that is no longer used, its words no longer change in meaning: therefore, the classification name of an organism will have a specific meaning. Knowing a Latin-based language like Spanish, can help you to identify the meaning of species classifications. Even if you don't know Spanish but understand Latin roots, you may also decipher why a species got its name.

Ernie created this chart to classify an El Paso desert animal: Canis Latrans

Classification	Organism	Meaning
Domain	Eukarya	Organisms that have cells with a nucleus
Kingdom	Animalia	Multicellular organisms that breathe oxygen and reproduce sexually
Phylum	Chordata	Animals that have bilateral symmetry and have a dorsal nerve chord
Class	Mammalia	Animals that have live births, have hair or fur and feed their young with milk from mammaries
Order	Carnivora	Animals that eat the flesh of other animals
Family	Canidae	Of the dog family
Genus	Canis	Of the group: Wolves, Dogs, Coyotes and Jackals
Species	Latrans	"bark or roaring" dog (probably from its howl)

This animal's local name is taken from the Aztec word coyotl, which means "Trickster". Can you guess this animal's name? ______________________________

Ernie's El Paso Kingdom Research Page:

There are 6 Major Taxonomy Kingdoms, and El Paso has organisms from all of them! Help Ernie find the taxonomy of these organisms that live in the El Paso area.

Domain: Eukarya **Kingdom:** Protista, Animalia, Plantae, Fungi

Kingdom: Animalia **Organism:**

Classification	Organism	Meaning
Domain	Eukarya	Organisms that have cells with a nucleus
Kingdom	Animalia	Multicellular organisms that breathe oxygen and reproduce sexually
Phylum		
Class		
Order		
Family		
Genus		
Species		

Picture:

Choose ONE of these species to research:
Horned Lizard
Burrowing Owl
Tiger Salamander
Texas Brown Tarantula
Striped Whiptail Lizard
Cotton tail rabbit
Kangaroo mouse
Fairy Shrimp
Texas Rattlesnake

Kingdom: Plantae **Organism:**

Classification	Organism	Meaning
Domain	Eukarya	Organisms that have cells with a nucleus
Kingdom	Plantae	Multicellular organisms that are mostly photosynthetic and can produce their own food. Their cell walls are rigid.
Phylum		
Class		
Order		
Family		
Genus		
Species		

Picture:

Choose ONE of these species to research:
Creosote Bush
Ocotillo
Texas Sage
Buffalo Grass
Lechugilla Cactus
Prickly Pear Cactus
Yucca Plant
Tornillo Mesquite
Texas Soapberry Tree

Domain: Eukarya **Kingdom:** Protista, Animalia, Plantae, Fungi

Kingdom: Fungi **Organism:**

Classification	Organism	Meaning
Domain	Eukarya	Organisms that have cells with a nucleus
Kingdom	Fungi	
Phylum		
Class		
Order		
Family		
Genus		
Species		

Picture:

Choose ONE of these species to research:

Penicillium
Aspergillus
Chaetomium
Gymnoascus
Podaxis

Kingdom: Protista **Organism:**

Classification	Organism	Meaning
Domain	Eukarya	Organisms that have cells with a nucleus
Kingdom	Protista	
Phylum		
Class		
Order		
Family		
Genus		
Species		

Picture:

Choose ONE of these species to research:

Eimeria
Falciformes,
Eimeria Nieschulzi,
Eimeria
indianensis
Algea such as *Polytomella*

Domain: Archaea **Kingdom:** Archaea

Kingdom: Archaea **Organism:**

Classification	Organism	Meaning
Domain	Archaea	Prokaryotic, unicellular, anaerobic organisms
Kingdom	Archaea	Single-celled organisms that do not have a cell nucleus and do not require oxygen to survive
Phylum		
Class		
Order		
Family		
Genus		
Species		

Picture:

Choose this species to research or research other species of archaea

Crenarchaeota

Domain: Bacteria **Kingdom:** Bacteria

Kingdom: Bacteria **Organism:**

Classification	Organism	Meaning
Domain	Bacteria	Prokaryotic, unicellular, aerobic organisms
Kingdom	Bacteria	Single-celled organisms that do not have a cell nucleus and need oxygen to survive
Phylum		
Class		
Order		
Family		
Genus		
Species		

Picture:

Choose ONE of these species to research:

Microcoleus
Cyanobacteria
Clostridium
Actinomycetes
Pseudomonas
Nitrobacter

Try this: Build your own Winogradsky Column

The Winogradsky Column is a simple device, invented over 100 years ago, that is still used by scientists to see if life can flourish even where there is little or no oxygen (O2) like the type we breathe in the air. In this exploration, you will build a Winogradsky Column, giving your ecosystems water and some food, in the form of carbon (C) and sulfur (S). Hopefully, it will get a pretty gradient of colors. The colors are the different bacteria that grow inside the column. Here are the type of bacteria that live in your Winogradsky Columns:

Position in Column	Type of Organism	Organism Examples	What color they look like in your column
Top	Photosynthesizers	Cyanobacteria	Green or reddish-brown layer. Sometimes bubbles of oxygen.
	Nonphotosynthetic sulfur oxidizers	*Beggiatoa*, *Thiobacilus*	White layer.
	Purple nonsulfur bacteria	*Rhodomicrobium*, *Rhodospirilum*, *Rhodopseuodmonas*	Red, purple, orange, or brown layer.
	Purple sulfur bacteria	*Chromatium*	Purple, or purple-red layer.
	Green sulfur bacteria	Chlorobium	Green layer.
	Sulfate Reducing Bacteria	Desulfovibrio, Desulfotomaculum, Desulfobacter, Desulfuromonas	Black layer.
Bottom	Methanogens (archaea)	Methanococcus, Methanosarcina	Sometimes bubbles of methane.

In this exploration, you will create four (4) separate Winogradsky Columns:

- a control with no added nutrient source
- one with only a sulfur nutrient source
- one with only a carbon nutrient source
- one with both sulfur and carbon.

Each column will create its own ecosystem.

You will need to be patient when waiting for results in your Winogradsky Columns. Typically, flourishing ecosystems and color changes require several weeks to grow. (Remember, the organisms that you are growing are very small, so small in fact that thousands could fit on the period at the end of this sentence.) Your column also demonstrates the concept of "succession" within an ecosystem. Different organisms eat and use up certain nutrients, and as those nutrients become depleted, new organisms take their place, often using the waste product of the previous organism as food.

Exploration: Build Your Winogradsky Columns

Purpose:

To build a model of an ecosystem that will host both bacteria and archaea organisms, understand that ecosystems thrive in a variety of harsh conditions and that living organisms can live in a variety of environments. Water is an important part of all ecosystems.

Materials:

- 4 clear plastic water bottles (tall and narrow with a smooth inside)
- Plastic gloves
- Scissors
- Marker
- Ruler
- Trowel or shovel
- Soil from the outdoors, (quicker results would be from a ponding area, but a garden will do)
- Two buckets
- Newspaper or plain paper (shredded)
- A boiled egg
- Two smaller bowls
- Two large mixing bowls
- Measuring cup or scoop
- Wide stick
- Measuring spoon
- A warm area to place your Columns
- Plastic wrap
- Plastic trash bags or grocery bags
- Four rubber bands
- Cardboard box or brown paper bag
- Camera (optional)

Procedure:

1. Carefully cut off the tops of your bottles using scissors. Individually label the bottles Control, Carbon, Sulfur, and Carbon + Sulfur.
2. In a bucket, collect enough mud from a ponding area to fill all four of your bottles plus a little extra. If you are using 1 liter bottles, collect 5 liters of mud. Try to avoid large pieces of material such as twigs or leaves or roots. The mud should be saturated with water. You will need enough mud to fill each of your bottles about 80% full.
3. Collect enough water from a pond to cover your mud. Water that has been left outside for a night will also work. Keep the water separate for now.
4. In the first mixing bowl, transfer enough mud to fill your bottle full twice to the mixing bowl, removing any twigs, leaves or rocks. Break apart any large clumps of dirt. Add water until the mixture is the consistency of a fruit smoothie.
5. Transfer enough mud from the bowl to fill your Control bottle 80% full. Tap the bottom of the bottle against a solid surface to remove air pockets. You may use the wide stick to push down the dirt, but do not pack it tightly.
6. Back in the first mixing bowl, repeat Step 4, but this time add a sheet of shredded newspaper or plain paper. Mix the paper into the mud until it is thoroughly mixed in.
7. Repeat step 5, but to the bottle labelled "Carbon."
8. In the second mixing bowl, repeat Step 4, but this time add your hard-boiled egg. Mix thoroughly.
9. Repeat Step 5, but to the bottle labelled "Sulfer"
10. Add the remaining Carbon and Sulfur mud together and mix.
11. Repeat Step 5, but to the remaining bottle "Carbon + Sulfur"
12. Pour the remaining water into each bottle until each bottle is about 90% full.
13. Cover each bottle tightly with plastic wrap.
14. Set each bottle in a warm environment near a lit window, but not in direct sunlight. Let the water settle.

Observations:

1. Using your Winogradsky Worksheet, design a table to record your observations of your Winogradsky Columns. You may want to include: colored drawings or pictures of the columns, colors observed, position in the column that it was observed, guesses as to which bacteria or archaea may growing in the column, and justifications as to why you believe that this organism may be archaea or bacteria based on the information table given on page 1.
2. Record what the Winogradsky column looks like every 4 days for 5 weeks. Record any changes in colors and mark where each different color shows up in the column. Some of the colors might be very subtle, so look closely.

*Optional: Take a picture every 4 days for 4 weeks of your column and see how the colors change. Place the pictures in your observation journal or worksheet.

Results

In previous explorations (Water is Life I) you looked for signs of life in your dirt sample after water was added. These signs included movement and bubbles. What signs of life did you find in your Winogradsky Column?

Did your column have the same results as others?

How did the colors change based on the nutrient type?

Did colors change over time? How?

List some of the variables you could change in this exploration.

Extensions

- Do the same exploration, but change the source of the mud.
- Do the same experiment but change the amount of light / temperature / water.

Design an Observation Table

Using this Winogradsky Worksheet, design a table to record your observations of your Winogradsky Columns. You may want to include: colored drawings or pictures of the columns, colors observed, position in the column that it was observed, guesses as to which bacteria or archaea may growing in the column, and justifications as to why you believe that this organism may be archaea or bacteria based on the information table given on page 1.

Video link to accompany Winogradsky Column

Build your own Winogradsky Column: https://youtu.be/yl5BVQYwR0w