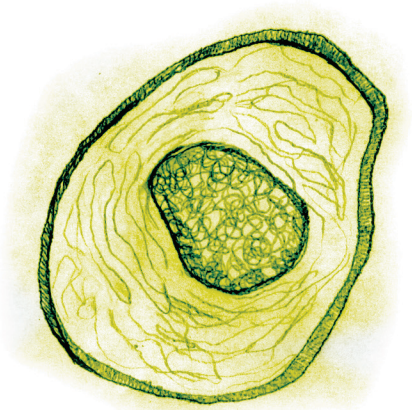
DARWIN 2009

Exploration is Never Extinct



Evolution of Metabolism

Puzzle Race Lesson Plan

grades 3-6

RegMed

REGENERATIVE MEDICINE

THE FUTURE OF HEALTH

Planetarium shows, movies and educational web tools

www.sepa.duq.edu

Lesson Plan by **Brinley Kantorski, Kylie LaSota,** and **Allison Pogue**

Layout Design by **Kevin Miller**

Darwin 2009: A Pittsburgh Partnership

Duquesne University · Carnegie Science Center · children's museum Pittsburgh · Carnegie Library of Pittsburgh · Pittsburgh Zoo & PPG Aquarium · Carnegie Museum of Natural History · National Aviary · PHIPPS

Produced by Regenerative Medicine Parnership for Education

Duquesne University

Director **John A. Pollock** - pollock@duq.edu

Art Director **Joana Ricou** - jiricou@gmail.com

Principle funding from

Science Education Partnership Award

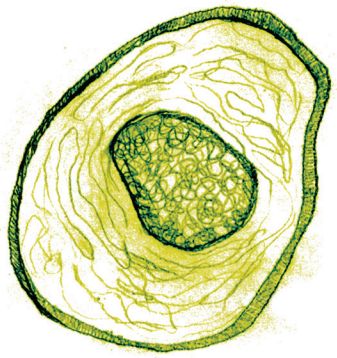
National Center for Research Resources

National Institutes of Health

SEPA

National Center for Research Resources

National Institutes of Health



Introduction

Evolution of Metabolism

DARWIN 2009
Exploration is Never Extinct

This lesson plan was developed as part of the "Darwin 2009: Exploration is Never Extinct" initiative in Pittsburgh. Darwin2009 includes a suite of lesson plans, multimedia, on-line resources and art. Find all information on-line at: **www.sepa.duq.edu/darwin.**

This lesson plan was originally developed for the Pittsburgh Zoo & PPG Aquarium in Pittsburgh, PA.

Special Thanks to Mike Henessy, Bryan Abraham, Azur Cherin.

CARNEGIE SCIENCE CENTER
One of the four Carnegie Museums of Pittsburgh

This activity consists of two parts:

Pre-Movie Discussion: 10-15 min

Post-Movie Activity: 40 min

Goals

1. To introduce the concepts of: the evolution of multicellular organism metabolism, cooperation, specialization.
2. To reveal that bigger, more complex organisms need specialization and cooperation.
3. To prepare students to watch the movie, *Our Cells, Our Selves*, and allow students to dig deeper into the concepts in the movie.
4. To allow students to practice using scientific methods such as hypothesis generation, data collection, and data analysis.

Learning Objectives

Students will be able to:

1. define multicellular, metabolism, cooperation and specialization.
2. apply the concepts of cooperation and specialization.
3. connect how metabolism changed as organisms became more complex.
4. create a hypothesis, collect data and analyze data.
5. compare and contrast cooperation and specialization.

Materials, Resources, and Preparation for Post Activity

- Handout 1 (pages 10-12, 1 copy for each student)
- Print document "Puzzles for Puzzle Race.pdf" which contains handouts 2-14 (1 copy per set of 5 "organisms" - see page 7 for details)
- Scissors for each "eater"
- Transparent tape for each "builder"

A few things your students should already know:

Before starting, the sutdents should be familiar with the following terms:

- Cell
- Organism
- Digestion
- Evolution

Teacher Pages

Evolution of Metabolism

Vocabulary

1. **Cooperation -** When talking about a multi-cellular organism, cooperation means that cells can share jobs and resources. For example, multiple cells can bind together for protection. Cells do not have special jobs.
2. **Metabolism -** the process an organism uses to break down food for energy, and then use that energy to grow, reproduce, and maintain its body.
3. **Multi-cellular -** an organism that is made of more than one cell.
4. **Specialization -** when different cells in an organism have different and complementary roles.

Overview

Metabolism

All organisms, no matter how big or small, and all the cells that compose them, need energy to survive. Metabolism is the process by which a life form gets energy from its environment and uses it to live. Metabolism includes eating food, breaking it down into nutrients, and using these nutrients to build new cell parts. Breaking down food gives us energy. Every cell in every organism needs energy to live so they can move, eat and build new cell parts.

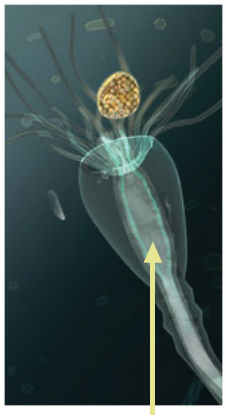
Some cells evolved to to eat smaller cells.

All cells are able to absorb small particles from their environment and digest them for energy. The very first organisms were all single-celled. These cells could get all their energy from the ocean and the sun. They absorbed and digested what they could by themselves.

Then, some cells appeared that had the ability to swallow other smaller cells. These cells were able to get energy a lot faster! These swallowing cells became central to the development of more complex digestion and immune systems.

Millions of years ago, cells started to be able to work together. Organisms evolved to be multi-celled instead of being single-celled, like an amoeba. This **cooperation** allowed the cells that make up these tiny multicellular animals to start **specializing**, and carry out different roles. The bigger the organism, the more specialized cells it needed. Some cells on the outside of the animal became tougher to protect the animal like a sort of skin. Some cells became really good at absorbing food, so they took control of eating. In very small animals, this works very well because all cells are very close to the cells that absorb food, so they can easily share energy with their neighboring cells.

Over time more complex organisms with more and more cells and a greater need for energy appeared.



The obelia above has a stomach pocket where digestion

Extracellular Digestion

Some cells formed stomach-like pockets, which became special areas devoted to eating, like a kind of stomach.

In the obelia to the left, we can see a special pocket or cavity. This pocket is lined with special cells that release chemicals into the pocket. These chemicals break down food as it comes in. These different cells cooperate to break down and absorb the food, and then share the food energy with their neighboring cells. As you can see, digestion started to occur more outside each cell, in the digestive pocket – this is called extracellular digestion.

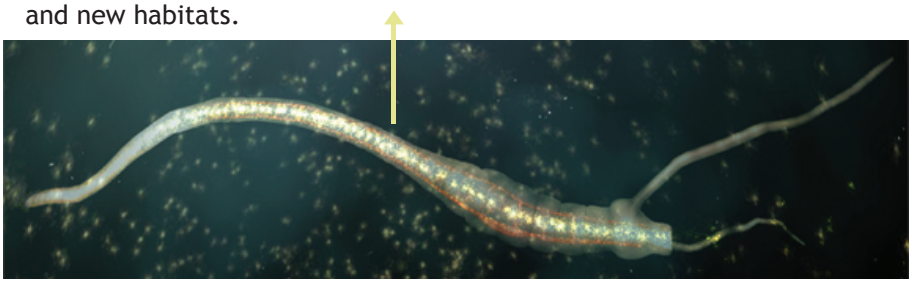
Distribution System

As animals got larger, the cells far away from the stomach pocket couldn't easily get energy from food. So, larger animals evolved passageways that traveled through their whole bodies to distribute energy and oxygen to all their cells. These passageways evolved to become blood vessels!

Larger animals also need more energy, so the stomach pocket elongated to form a passageway through the center of their entire bodies called the **gut** or **digestive tube**. This digestive tube allows the outside environment—the ocean and all its nutrients—to pass through the animal in a safe way while giving it lots of time to absorb as much food as possible. The digestive tube was better than a digestive pocket for large animals because it allowed them to:

- take in more food
- digest a larger variety of food
- digest the food outside the cells longer (making smaller pieces)
- start to separate the digestion of food from the absorbtion of the digested food (like our stomach and intestines)
- easily share the food with all of the cells of the organism

All of these things allowed larger organisms to get more energy and thus allowed them to move around more quickly to find new food sources and new habitats.



In the giant worm above, long passageways transport food and oxygen.

Evolution of Metabolism

Time: 10-15 minutes

Discussion Questions

Get your students to start thinking about the concepts in the movie by asking your students the following questions.

1. **Why do we need to eat?**

   Food gives the cells that make up our body the energy they need to live.

2. **Where does food go when we eat?**

   It starts out in the stomach where it's digested, and then travels to the intestines where the digested food is absorbed and sent to all the rest of the cells in the body.

3. **Do all animals eat the same things? In the same ways? What are some different ways of eating?**

   Animals eat lots of things in lots of different ways. Most animals have mouths with teeth like us, but birds have beaks and don't chew their food, some whales strain their food called plankton between large strainers in their mouths.

4. **What about plants? Do they eat?**

   Most plants don't eat in the way that we think of animals eating, but they need energy as well, and most get their energy from the sun, the air and the soil. Some plants, like the venus fly trap, actually do trap and digest other living things.

Play the Movie *Our Cells, Our Selves*
The movie is 12 minutes long.

Enjoy the show!

Post-Movie Activity
Evolution of Metabolism

Time: 40 minutes

Discussion

Start this activity by asking your students some Reminder Questions:

1. **Does anyone remember what metabolism is?**

   The process an organism uses to break down food for energy, and then use that energy to grow, reproduce, and maintain its body.
2. **What kind of animals did you learn about in the movie?**
3. **Did they all get energy the same way?**
4. **What is an example of a simple organism?**

   Amoeba, obelia
5. **What is an example of a complex organism?**

   Fish, humans, sharks
6. **What does it mean to be multicellular?**

   An organism made of more than one cell.

Overview

Students will explore the two different aspects of metabolism: breaking down food for energy and spending energy to help the organism live.

The students pretend to be the "cells" of different "organisms" and they race to put together a puzzle. The overall activity is a metaphor for metabolism: how we break food down into smaller parts to get energy to put the pieces together in new arrangements to build our bones, muscles and other parts of our bodies. Students will play different roles: "Eaters" will cut apart the scrambled puzzle and "Builders" will put the puzzle together. Some students will act as both Eaters and Builders, and others will only have one job. More complex "organisms" build bigger puzzles than simpler "organisms."

Each final puzzle is a picture of each "organism" with spots for their organism Name, their Starting and Final times, some facts about the organism and a discussion question.

Puzzle Race

To explore the two concepts of cooperation and specialization, students will have one of two roles:

1. The "Eaters," which represent the part of the organism that breaks down energy.
2. The "Builders," which represent the part of the body that spends energy to help the organism live.

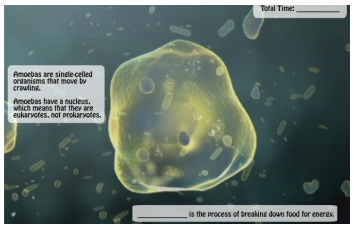
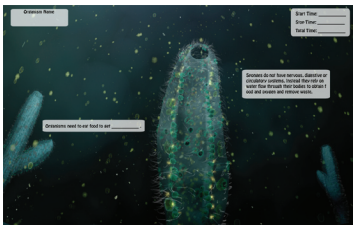
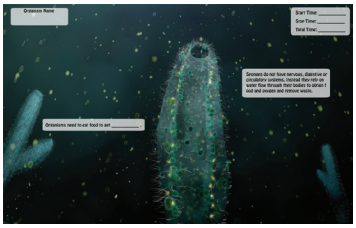
Teams

- There will be at least one team of 1, two teams of 2 and two teams of 4 students.
- If you have more students, they should be assigned repeat organisms so averages can be calculated later.

How to Play

1. Pass out Evolution of Metabolism Handout #1 to your students and explain the activity.

Each student (or team of students) will be responsible for one kind of organism, according to the table shown below.

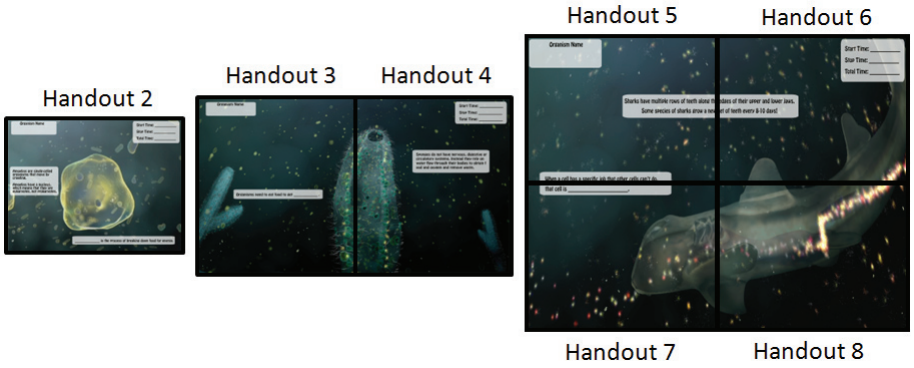
Puzzle Picture	Organism	# of	# of	# of	# Eaters/
 Handout #2	**Amoeba** The amoeba is a single-celled organism. *(The student can't cooperate or specialize.)*	1	0	0	1
 Handouts #3 & 4	**Sponge** The sponge is a simple multicellular organism. *(The students cooperate, but don't specialize.)*	2	0	0	2
 Handouts #3 & 4	**Sponge** The sponge is a simple multicellular organism. *(The students cooperate and are specialized.)*	2	1	1	0
 Handouts #5, 6, 7 & 8	**Shark** Sharks are complex multicellular organisms. *(The students cooperate and don't specialize.)*	4	0	0	4
 Handouts #5, 6, 7 & 8	**Shark** Sharks are complex multicellular organisms. *(The students cooperate and are specialized.)*	4	2	2	0

2. Guide the students to make predictions about which organism will win, and why. Talk about how each organism has a team; ask the students:
   - Which organisms/teams are multicellular or single-celled?
   - Which teams have cooperation?
   - Who's responsible for metabolism?

3. Draw the following diagram on your board and have each student fill out their Hypothesis Table (on Handout #1) by predicting what order the organisms will finish their puzzles and explaining why they made those choices.

Order	"Organism"/Team	Hypothesis
	Amoeba	[Example: *I think the amoeba will be last because only one person has to do everything.*]
	Sponge	
	Shark	

4. When all organisms are ready, write the start time on the board and tell the students to begin. Tell them to raise their hands when they are finished.
5. While the students are racing, draw the table from Handout #1 on the board and fill in the team column.
6. As teams finish, write their End Times in that column on the board.
7. When the Puzzle Race is over, ask your students to calculate the total time each team took and record the values in the table on Handout #1.
8. Now, have your students calculate the average times for the different types of organisms.
9. Tape the completed organism puzzles on the board next to the results to show the evolution of metabolism (a suggestion of how to organize the handouts is below). Write the average time for each organism underneath its picture.



10. Each puzzle has a fill-in-the-blank question. Go over each question with the class.

The answers for the fill-in-the-blank questions are:

Amoeba: Metabolism is the process of breaking down food for energy.

Sponge: Organisms need to eat food to get energy.

Shark: When a cell has a specific job that other cells can't do, that cell is specialized.

Discussion

Here are some questions for the discussion. The goal of these questions (and the activity overall) is for the students to realize that the bigger and more complex an organism gets, the more specialization and cooperation it needs.

1. Did anyone choose the correct hypothesis?
2. Why do you think the fastest organism was the fastest?
3. Why do you think the slowest organism was the slowest?
4. What do the eaters represent?
5. What do the builders represent?
6. Give examples of eaters in the human body.

   Cells in the stomach, lining of the mouth, intestines, liver, pancreas
7. Give examples of processes in the human body that are like builders.

   Example: walking, running, thinking, making new bone and blood cells, etc.
8. What happens if you have specialization, but no cooperation?

   Example: Imagine if a car's steering wheel wasn't connected to the wheels!
9. How is specialization different than cooperation?

   Cooperation happens between cells that all do the same jobs, specialization is when cells do different things.
10. Are there other systems in our bodies that have specialized cells? Name some.
11. Can you think of another example of something in the world that has cooperation and specialization?

    Example: sports teams, cars, factories

-Evolution of Metabolism Handout 1-

Organisms need to break down food for energy. They break food down into small parts and then use those small parts to build new cells. In bigger organisms cells **cooperate**, and cells have different jobs - they are **specialized**.

Today, you are going to have a Puzzle Race! You will pretend to be an organism and will need to "eat" paper and then build a puzzle from the pieces. When you finish your puzzle, raise your hand!

Hypothesis:

Think about each of these different organisms. Which organism do you think will build the puzzle the fastest? Why do you think some organisms will be faster than others? Write down your hypothesis for each one.

Order	"Organism"/Team	Hypothesis
	Amoeba	
	Sponge	
	Shark	

Methods:

Ok, it's time to race! You will be divided into different teams and each person will have a job.

- "Eaters" will cut apart the puzzle.
- "Builders" will build the puzzle.
- Some will do both jobs!

Collect your materials from your teacher and follow his/her instructions.
**There is a question in the picture! What's the answer?*

Which job do you have (circle one)? **Eater** **Builder** **Eater & Builder**

Continues on next page.

Results and Calculations: How long did it take?

Record the results of the race here: Start time _____

Team	Organism	Number of Students	End Time	Calculation	Total Time
1	Amoeba	1			
2	Amoeba				
3	Amoeba				
4	Amoeba				
5	Amoeba				
6	Sponge				
7	Sponge				
8	Sponge				
9	Sponge				
10	Sponge				
11	Shark				
12	Shark				
13	Shark				
14	Shark				
15	Shark				

Which organism was the fastest?

Calculate the average time it took for each organism to complete the puzzle.

	How many of each organism?	Calculate the average here	Average Time
Amoeba			
Sponge			
Shark			

Conclusion: What do your results tell you?

In what organisms was cooperation better than specialization? In which organisms was specialization better? Discuss these questions using the race time averages as evidence.

What is the relationship between complexity and having cooperation or specialization?