Middle School Biofabrication Storyline

How Does An Axolotl Regenerate (regrow) Damaged Limbs?

BioFab/NGSS Preview (Teachers 🍎)
https://youtu.be/nozIG3HzfWM

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Unit Summary

In this unit, through the phenomenon of the mexican salamander (axolotl) being able to regenerate severed limbs, students engage in science and engineering practices to understand that all living things are made of cells. Additionally, students investigate that living things can be made of a single cell or many different types of cells. Building on the 3-5 grade span DCI that animals and plants have internal and external structures which serve various functions, students work from macro to micro/organ systems to cells as systems to deepen their understanding of living things.

Performance Expectations

MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]

MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.]

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. [Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.] [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]

Science and Engineering Practices

Planning and Carrying Out Investigations (LS1-1)

- Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.

Developing and Using Models (LS1-2)

- Develop and use a model to describe phenomena.

Engaging in Argument from Evidence (LS1-3).

- Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.

Obtaining, Evaluating, and Communicating Information (LS1-8)

- Gather, read, and synthesize information from multiple appropriate sources and assess the

Disciplinary Core Ideas

LS1.A: Structure and Function

- All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). **(MS-LS1-1)**
- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. **(MS-LS1-2)**
- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

Crosscutting Concepts

Scale, Proportion, and Quantity (LS1-1)

- Phenomena that can be observed at one scale may not be observable at another scale.

Structure and Function (LS1-2)

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

Systems and System Models (LS1-3)

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

Cause and Effect (LS1-8)

- Cause and effect relationships may be used to predict phenomena in natural

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credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	**(MS-LS1-3)**	systems. ***Connections to Engineering, Technology and Applications of Science (LS1-1)*** **Interdependence of Science, Engineering, and Technology** ● Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. ***Connections to Nature of Science (LS1-3)*** **Science is a Human Endeavor** ● Scientists and engineers are guided by habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

Time: 3 to 4 Weeks

Anchoring Phenomenon: The Mexican salamander (Axolotl) can grow back (regenerate) limbs without scarring.

Driving Question: How does the axolotl regenerate damaged limbs?

Possible Driving Question Board Categories: Humans & Other Organisms; About the Axolotl; Bones; Growing Back Body Parts (Regeneration)

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Lesson Number	Question(s) We Have	Phenomena (Investigative)	Science & Engineering Practices	What We Did (Activity)	What We Figured Out?/Learning Targets	How Does This Help Us Explain the Phenomenon?	Vocabulary
Introduce the Anchoring Phenomenon and the axolotl with a picture or video							
1A 15 minutes	What other living things grow back body parts?	Other living things grow back missing parts.	Asking Questions	From prior knowledge construct a class list of living things that regenerate and what they regenerate. All answers are documented (right and wrong). Those that cause disagreement or the class is unsure can have a question mark next to them.	Prior knowledge of regeneration and misconceptions	Other living things can regenerate & some cannot	**regenerate**
1B 30 Minutes	How does the axolotl regenerate limbs?	The axolotl regenerates limbs.	Developing and Using Models Constructing Explanations Asking Questions	Students work in small groups to model on white boards or poster paper how they think axolotls regenerate their limbs. They generate questions they	Students document their initial explanations of how the axolotl regenerate its limbs. The DQB is developed	The class has established a beginning understanding and lessons will help them build deeper understanding and revise their model to ultimately	

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				have about the anchoring phenomenon on post-it notes or paper. They use the questions to develop a Driving Question Board. The class develops a consensus model to explain their initial thoughts of the axolotl regeneration	The initial class consensus model is developed	explain the anchoring phenomenon	
2A 15 minutes	DQB questions about the axolotl that do not have to do with regeneration	Axolotls are unique salamanders	Asking Questions Obtaining, Evaluating, & Communicating Information	A quick Google search of some of the questions about the axolotl from the DQB that do not have to do with regeneration. Students share what they find. **Alternative:** to read and discuss a short article about the axolotl that does not go into detail about cells. Remove answered	Students learned more about the Axolotl as a living thing **(organism)**	Students have background info on the axolotl. Where they live, what they eat, how many offspring they have, how long they live, sicknesses, if they hibernate, do they have predators or prey (any information that does not have to do with regeneration). This will allow students to focus on the	**organism**

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				questions from the DQB and place on the Class Summary Table		Anchoring Phenomenon and question.	
2B 30 minutes	How are human and axolotl body structures the same and different?	Humans and axolotls have body structures that are similar and different	Asking Questions Constructing Explanations Engaging in Argument from Evidence	Step 1: Building on 3-5 knowledge of internal structure & function students use organ cards to connect the organs that work together into organ systems. Step 2: A card sort of organ systems that are similar & different for humans & axolotls **digestive system** (mouth, tongue, stomach, intestines, anus/clocea), **circulatory system** (heart, lungs/gills, veins, and arteries), **skeletal system**	The body of an axolotl or human is a system made of smaller parts called organ systems. These organ systems are made of smaller parts called organs (skin, muscles, bones; axolotls have gills-humans have lungs) Humans are not able to regenerate limbs	Axolotls are a system made of smaller parts.	**system** **organ**

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				(bones). Internal and external diagrams of both humans and the axolotl supplied. **muscular system** (muscles) **Nervous System** (brain,spinal cord, nerves) **Excretory System** (kidneys, ureters, bladder, urethra/clocea **Discussion Questions to pose:** Do you think each system works in isolation? Why or why not? Do you think any system is more important than the others? Why or why not? Explain how each system is related. Is the whole			

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				body a system? Why or Why not?			
3A 45 minutes	How do organ systems work together to make a body system?	Organ systems work together to make a body system.	Asking Questions Developing and Using Models Planning and carrying out investigations Analyzing and Interpreting Data Constructing Explanations Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating Information	**Chicken Wing Lab.** Students remove the skin and fascia from hygienically prepared chicken wings. They investigate how the muscular system works with the skeletal system to make a body system move. Students model to explain their findings. **Discussion:** What other organ systems work to help the body move? What happens if part of the system is damaged or broken?	Organ Systems work together. If parts of the system are damaged or broken the system does not work as well.	Summary Table is not revisited here	
4A 45 minutes	What makes up an organ? How small can we go?	Organs are made of smaller items	Asking Questions Analyzing and Interpreting	Students compare different tissue samples. This can be	Specialized material called tissues make up specialized organs	Axolotls have organs that are made of tissues.	**tissue**

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			Data Obtaining, Evaluating, and Communicating Information	accomplished through video, pictures or microscope with slides. **Discussion** of structure & function of the tissues. specialized tissues			
5A-B (2) 45 minute classes	What are tissues made from? How small can we go?	Tissues are made of something	Asking Questions Planning and carrying out investigations Analyzing and Interpreting Data Obtaining, Evaluating, and Communicating Information	Using microscopes and prepared slides with microscopic tissue samples students record and diagram their findings. **Extension:** Cheek Cell Lab. Students work from self-prepared slides to examine an example of one type of their cells **Alternative:** Use pictures with macro-version of living things and pictures of tissues of the same items at the micro level.	Tissues are made of microscopic structures called cells. Cells are systems. These cells are specialized based on their structure. Humans/students are organisms and are made of cells.	Summary Table is not revisited here	**cell** **nucleus** **mitochondria** **cell membrane**

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				Discussion to follow.			
6A 45 minutes	Are all things made of cells?	Tissues are made of cells.	Asking Questions Planning and carrying out investigations Analyzing and Interpreting Data Constructing Explanations Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating	Card sort of macro version of living and nonliving things and a card sort of the same items at the micro level. Plants are included in living things. Students record their findings. **Discussion to follow.** **Alternative**: Use microscopes with slides with microscopic versions of living and nonliving things. Students record their findings. **Discussion to follow.**	Only living things (organisms) are made of cells.	The axolotl is a living thing and is made up of cells	**cell wall** **chloroplast**
7A 30 minutes	Why are there so many different types of cells?	The axolotl has many different types of cells	Asking Questions Analyzing and Interpreting Data Constructing	**Discussion** of the observations of the structure of different cells observed in the previous activities (5A-	Specific cells have specific functions based on their structure	The axolotl has many different cells; bone, smooth muscle, nerve, skin, cardiac muscle, skeletal muscle, blood cells,	**multicellular**

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			Explanations Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating	6A) Possibly add a tool & function type of lab if needed for clarification		stem cells. Humans do too. The axolotl is a multicellular organisms with many different types of cells	
8A 45 minutes	How small are cells?	Cells are small	Using Models Analyzing and Interpreting Data Using Mathematics and Computational Thinking	Students use a computer simulation to understand the size of cells and scale. *Scale of the Universe Simulation* https://scaleofuniverse.com/ Students discuss how to show microscopic processes on their models	Cells are so small they cannot be seen without the technology of microscopes. Cells are the smallest system considered living	The cells of the axolotl are so small they cannot be seen without the technology of microscopes	**scale microscopic**
9A 45 minutes	Do all organisms have different types of cells	Axolotls have many different types of cells	Asking Questions Planning and carrying out investigations Analyzing and Interpreting Data	Pond water lab/single celled organisms on slides lab. Students record their observations	Some organisms are made of a single cell some are made of trillions of cells		**unicellular microorganism**

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			Constructing Explanations Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating				
10A 3 Multiple Days	How do cells survive? How do we keep our cells healthy?	Cells are living things that survive or do not survive	Asking Questions Developing and Using Models Planning and carrying out investigations Analyzing and Interpreting Data Using Mathematics and Computational Thinking Constructing Explanations Engaging in Argument from Evidence Obtaining,	Salt water with cells (osmosis) Egg corn syrup lab (diffusion) Students model the processes of osmosis and diffusion on white boards or poster paper Class consensus model developed **Discussion**	The cell membrane regulates what enters and exits a cell	Axolotl's cells regulate what enters and leaves through the cell membrane	**osmosis** **diffusion** **cell membrane** **semi-permeable**

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			Evaluating, and Communicating				
11A 30 minutes	How do the cell membranes of the axolotl's cells help the axolotl survive?	The cell membranes of the axolotl's cells help the axolotl survive	Asking Questions Analyzing and Interpreting Data Constructing Explanations Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating	Discussion of the cell membrane Structure & Function	Living things need food, water, a way to dispose of waste,	The axolotl's cells receive food and water and remove waste through the cell membranes	**cell membrane**
12A 45 minutes	How do humans heal when damaged?	Humans can heal when damaged	Asking Questions Developing and Using Models Analyzing and Interpreting Data Constructing Explanations Engaging in Argument from Evidence Obtaining,	Video on body healing damaged skin & bone Students model formation of scar tissues (cellular level) **Discussion** Includes students thoughts on other organ systems involved in an immune response	Humans grow new cells, but they do not regenerate parts. The human immune system protects the body when damaged	Human systems react differently than the axolotl system when damaged	**immune system**

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			Evaluating, and Communicating				
13A 45 minutes	Why can't humans regenerate?	Humans do not regenerate	Asking Questions Analyzing and Interpreting Data Constructing Explanations Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating	Video clip of embryonic development. (unspecialized cells forming specialized cells) Discussion Reviewing Lessons 5A-7A	Multicellular organisms develop from unspecialized cells. Specialized cells do not change into other specialized cells. Humans do not have unspecialized cells ready to change and form new tissue-organs-organ systems-limbs	Axolotls have cells that are specialized and cells that are not specialized available to become needed specialized cells-specialized tissues-organs-organ systems	
14A 45 minutes Assessment 1	How can we explain that axolotls have unspecialized cells that form new specialized cells-tissues-organs-organ systems?	Axolotls have cells that are specialized and cells that are not specialized available to become specialized cells-specialized tissues-organs-organ systems	Asking Questions Developing and Using Models Analyzing and Interpreting Data Constructing Explanations Engaging in Argument from Evidence Obtaining,	Students revisit their original model of the axolotl regenerating limbs and revise Consensus model developed	Multicellular organisms are made of a tremendous amount of specialized cells that form tissues - organs - organ systems - whole organism cells have structures with specific functions that work together as a system a cell is the smallest system	**Gotta Have List** specialized cells non specialized cells cell membranes nuclei mitochondria How cells get water, energy, remove waste cells tissues organs organ systems organism change over time of non specialized cells	**regenerate** **cell** **nucleus** **mitochondria** **cell membrane** **tissue** **system** **organ** **organism** **osmosis** **diffusion** **cell membrane** **semi-permeable** **unicellular** **microorganism** **scale** **microscopic** **multicellular**

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			Evaluating, and Communicating		that	forming specialized cells to regenerate damaged limbs (working on writing this as relationships not a list of vocabulary)	
15A 45 minutes	How are medical advances connected to the regeneration of cells, tissue and organs	Medical advances and Bio-engineering are connected to the regeneration of cells, tissues, and organs	Obtaining, Evaluating, & Communicating Information	Axolotl Scientist Video? Article/video on regeneration of cells, tissues, and organs. See resources for BioFab NGSS videos **Discussion**		The study of axolotls has advanced bio-engineering technologies and the understanding of scientists in the field	**bioengineering**
16A Assessment 2 (CER) 45 minutes			Analyzing and Interpreting Data Constructing Explanations Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating	Using their understanding of cells, students write a Claim Evidence Reasoning (CER) based on why humans cannot regenerate limbs and axolotls can.			**claim evidence reasoning scientific argument**
17A Assess	Students apply the scientific principles from this unit to a new phenomenon.						

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ment 2 45 minutes	**Examples:** **#1 A sample of material from a scientific expedition in a remote area was recently discovered and it is your job to identify if this is evidence that life existed in this area. What evidence could you look for to support whether the material was living or non-living and what is your reasoning to support whether this sample would be classified as living or non-living?** **#2 Maria was skateboarding along the sidewalk when a squirrel ran directly in front of her. She just barely misses the squirrel.** **a. Does Maria stay on her skateboard or does she fall?** **b. List the body systems Maria uses to avoid hitting the squirrel.** **c. Explain what each system you listed does to help Maria as she misses the squirrel.** **d. How are cells related to Maria's body response to that squirrel?**

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1. Introduce the *anchoring phenomenon*
2. An initial *formative assessment* of the students' initial explanation through modeling (if possible) of the *anchoring phenomenon*
3. Development of the *Driving Question Board (DQB)*
4. *Instructional phenomena* address questions from the categories on the *(DQB)* and connect back to the original anchoring phenomenon as they understand the scientific principles addressed. Students figure out the scientific principles.
5. Students return to their original model and revise incorporating what they have learned into their model/explanation
6. Initial Assessment: CER
7. Final Assessment: apply the principles to a new situation

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