Shape of Life
The Story of the Animal Kingdom

Artful Echinoderms

Engaging Students with Echinoderm Phenomena, Adaptations, and Art

Overview

The lesson begins with students engaging in the practice of science – observing phenomena, describing their observations, and making sense of what they see. They observe echinoderm behaviors using a Shape of Life video with the audio turned off. They try to figure out what the phenomenon (the behavior) is and how it might help the organism survive. Working with a partner, they make hypotheses about what they are observing and the organisms' adaptations that allow it to perform the behavior. They present ideas to the class, using evidence to support them. Next, they examine echinoderm art, read about echinoderms and their amazing adaptations, and view additional videos with a partner. Then they use what they discovered to create original works of art and/or engineering. Enrich/Extend activities are listed at the end of the lesson to help engage all learners.

Subjects

Science, Reading, Writing, and Art

Grades

Adaptable for 3 – 12

Time

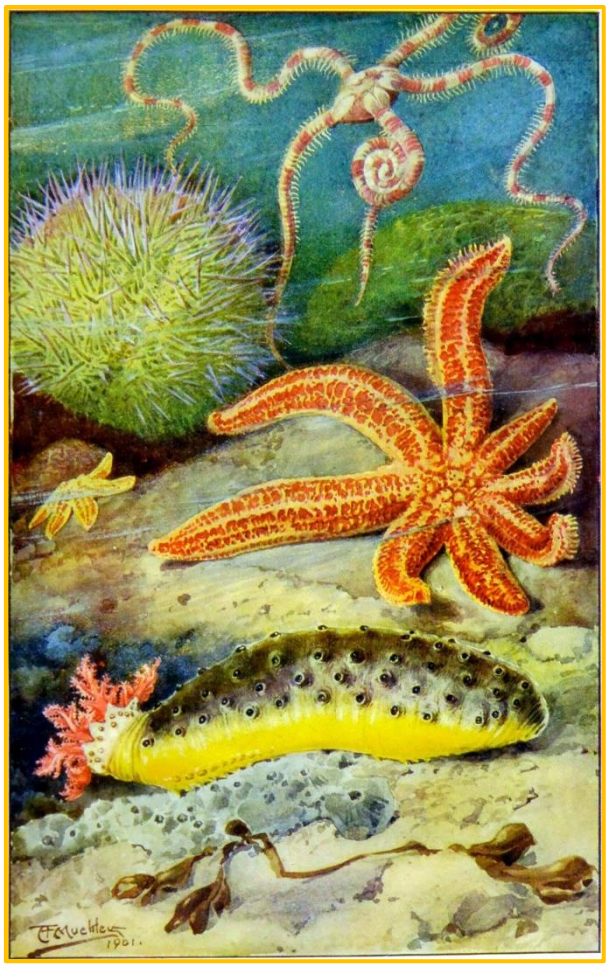
40 – 90 minutes or more

Vocabulary

Biological evolution, brittle star, crinoid, echinoderm, eversible stomach, model, nerve ring, sea cucumber, sea urchin, sea star/starfish, phenomena, radial canal, radial symmetry, tube feet, systems, water-vascular system

Objectives

- Students will brainstorm and discuss possible explanations of an observed phenomenon.
- Students will use evidence to support their ideas orally and in writing.
- Students will explain echinoderm adaptations orally, with art, and in writing.



Artful echinoderms dazzle in this painting. Can you name them?
From The Natural History of Animals *by J.R. Ainsworth Davis, 1903 – 1905: wellcomecollection.org/works/kb3pmra.*
A larger version of the color plate is shown in the "Artful Echinoderms" activity at the end of the lesson.

Answers, from top:
A brittle star, sea urchin, sea stars (starfish), and sea cucumber

Standards		Middle School / High School
Next Generation Science Standards	Performance Expectations	MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. MS-LS4-2: Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
	Sample Disciplinary Core Ideas met	LS1: From Molecules to Organisms: Structures and Processes LS1.A: Structure and Function LS1.B: Growth and Development of Organisms LS4: Biological Evolution: Unity and Diversity LS4.C: Adaptation LS4.A: Evidence of Common Ancestry and Diversity
	Crosscutting Concepts	• Cause and effect • Structure and function • Systems and system models • Patterns
	Science & Engineering Practices	• Developing and Using Models • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence • Obtaining, Evaluating, and Communicating Information
Common Core ELA	Writing	7
	Speaking & Listening	4, 6
	Language Standards	1, 2, 3, 6

Teacher Background

See the "Echinoderms Fact Sheet" for background information about the phylum. The printable handout and other resources are available here: shapeoflife.org/resource/about-echinoderms.


Shape of Life

Echinoderms Fact Sheet

Spiny Rebels

Echinoderms are like no other animals on Earth. They include sea stars, sea urchins, sea cucumbers, and the striking flower-like sea lilies (crinoids). These animals have a unique body plan and a unique way of moving and feeding.

Most of today's animals have a bilateral body plan—but not these spiny rebels. Evidence suggests that early echinoderms, which evolved over 500 million years ago, also had bilateral symmetry. However, they eventually evolved away from that plan. Instead, every echinoderm is based on a five-part body that interacts with the world equally from all directions. And unlike most animals, they don't have heads with brains to lead the way!

Crinoids (sea lilies) first evolved about 480 million years ago.

Hunters and Grazers of the Sea

Echinoderms live only in the ocean, where they play critical roles in marine ecosystems. Most are slow-moving or stationary, yet many (like most sea stars) evolved to become successful predators (hunters). Sea urchins became unstoppable grazers. Their phylum name Echinodermata means "spiny skin" in Greek. But their special adaptations are more than skin-deep.

All echinoderms have five-part radial symmetry.

Sea star | Legs folded tip-to-tip | Sea urchin

Five Shared Adaptations of Echinoderms

- Five-part Radial Symmetry

  Their five-part body plan is symmetrical around an axis centered on the mouth. This is easy to see in a five-armed sea star. Rounded sea urchins have a spherical body with the same basic body plan. They are like sea stars with their five arms folded up tip-to-tip. Sea cucumbers have the same five-part body plan stretched into a long tube. Watch "Echinoderm Animation: Five-part symmetry": shapeoflife.org/video/echinoderm-animation-five-part-symmetry

- An Internal Skeleton

  Their skeletons are made of small plates of calcium carbonate covered by thin skin. Tough connective tissue and small muscles hold the plates together and allow the sea star to be amazingly flexible. Urchins have structures attached to these plates that connect to their moveable spines.

The small plates of a sea star's skeleton are held together by connective tissue and small muscles, as shown in this illustration.

- A Water-Vascular System

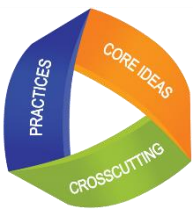
  A fluid-filled system in their bodies powers hundreds of tube feet.

  - The radial canal brings in sea water to power the water vascular system and connects to all the tube feet in the organism.
  - Tube feet are the working ends of the water-vascular system. They aid in locomotion, grasping, and respiration. The organism extends a foot by increasing the pressure inside a small muscular bulb, which pushes the tube foot out. Tube feet on the bottom of

Illustration of the tube feet in a sea star, connected by the radial canal.

Echinoderms Fact Sheet - Page 1 of 2 Shape of Life

This lesson uses **phenomena-driven inquiry**. This is the process of using observable scientific phenomena to engage students and help guide the learning process. It can be used as part of **Three-Dimensional Learning** referred to in the Next Generation Science Standards (NGSS) to weave together the Science and Engineering Practices (SEPs), Crosscutting Concepts (CCs), and Disciplinary Core Ideas (DCIs) in student learning. Through the process of DOING science and engineering, students apply the Three Dimensions, helping them see the interconnections among disciplines as they develop their scientific, critical thinking, math, and English Language Arts (ELA) skills. This will help prepare students to conduct their own meaningful and informed investigations.



Art as Inquiry

Integrated STEAM programming can use artmaking / design in such a way that the art inquiry and the science inquiry mutually reinforce each other, deepening and adding nuance to the understandings in both domains. This approach is different than exploring a science concept and then making an explanatory drawing of it, which positions the concept of art as a tool that can be summoned, fully formed, to neatly communicate science learning. In some cases, this is true. But art is also a process of inquiry through which knowledge is generated, and as such, it is burdened with assumptions that are worth unpacking, confined by skills that are worth reflecting upon and recognizing that they develop slowly over time, and are bounded by the resources, tools, and time available. As a learning approach, the value lies in familiarizing students with this process of creative inquiry / generative expression / problem solving, and fostering their ability to critique and reflect on it, rather than arrive at any specific artifact.

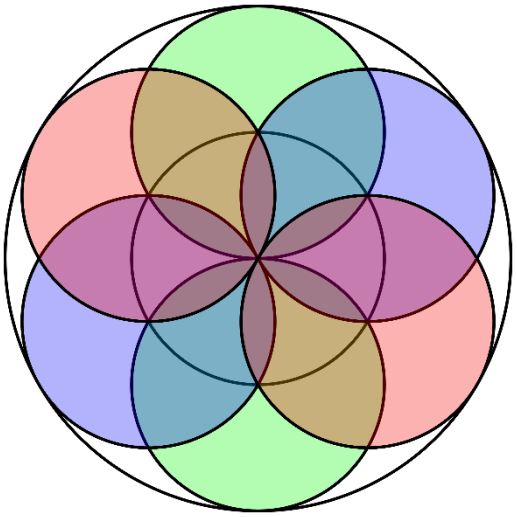
Note:

- "Art" and "making" are used to refer to art / applied arts / design inquiry which, although distinct, revolve around a similar core set of practices and approaches to generating knowledge.
- ALL making is beneficial. Any opportunity to push creative expression and explorations around manipulating the material world is positive, especially in today's digitally mediated reality, in which the skills of thinking through our interactions with the physical world are deemphasized. It is important to open room for making / art and creativity.

Scaffolding Art Inquiry

Implementing art- or design-based inquiry can be challenging. This lesson highlights some of the many opportunities to engage with art practices / processes that complement STEM learning in a meaningful way. We suggest a variety of options. It can be helpful to provide structure for students, especially with those who are younger or less experienced.

Scaffolding an inquiry by offering an exemplar activity, while also allowing student choice, is a good approach. See project examples that you could step students through in the Explore and Extend / Enrich sections of the lesson. For example, creating **mandalas** is a great activity with clear aesthetic principles, cultural connections, and even established benefits to emotional regulation and introspection. A thematic connection to emphasize and explore is how mandalas contain a unit of information that repeats multiple times, rotated around the center point. If you create a mandala on a sheet of paper and cut it through the center, each piece will still contain that essential unit of information. You could give this fragment to a friend, and they could use it to regenerate a full mandala just like the original one, not unlike how an echinoderm can regrow arms and even whole bodies from one part!



A simple mandala with its beautiful, repeating radial symmetry
Free SVG: freesvg.org/seed-of-life-2

If you create mandalas, try to help students see the connections between the science and art, such as between the radial symmetry in your designs and the **five-part radial symmetry** of echinoderms. Ask them to think about and discuss how drawing mandalas can help us understand the benefits of a radial body plan. By working through a tightly scaffolded exemplar, such as the mandala activity listed first in the Extend / Enrich section, you and your students will get a better sense of how these conceptual connections can help to apply this kind of interwoven approach to a broader range of activities of your or your students' own choosing.

Materials + Preparation

- One or more short Shape of Life videos showing echinoderm behaviors, such as:
  - "Echinoderms: Sea Star Time-lapse: Eating Dead Fish" (1:36): shapeoflife.org/video/echinoderms-sea-star-time-lapse-eating-dead-fish

  - "Echinoderms: Sea Star Time-lapse: Eating Mussel" (2:47): shapeoflife.org/video/echinoderms-sea-star-time-lapse-eating-mussel

- Copies of the "Echinoderms Fact Sheet" from Shape of Life for each student
- Science notebook and pencil or pen for each student
- Computer with Internet connection and data projector
- Whiteboard or chart paper and markers

Teaching Suggestions in the 5E Model

Engage

1. Students observe an echinoderm behavior and generate ideas about how/why it happens. (5 – 7 min.)

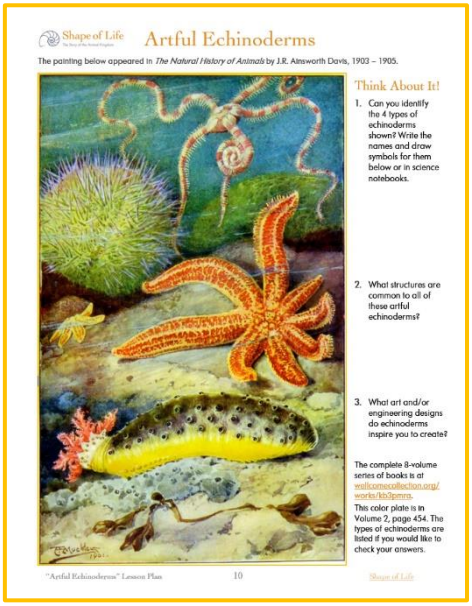
   - Show students a short Shape of Life video about an echinoderm behavior. Mute the audio and turn off closed captioning (if applicable). One engaging option is "Echinoderms: Sea Star Time-lapse: Eating Dead Fish" (1:36): shapeoflife.org/video/echinoderms-sea-star-time-lapse-eating-dead-fish
   - Ask students to think about how to describe the behavior and what is going on in the video. Invite them to record their ideas in science notebooks, including anything they may have already learned about sea creatures like these.
   - After a minute, invite them to turn to a neighbor to discuss their ideas. Ask them to record additional brainstormed ideas in science notebooks. After a minute or two, invite the partners to share their best ideas with the class.

- Show the muted video again and discuss the student ideas. For example, what are the organisms called, what are they doing, and why? Ask them to use evidence to support their ideas.
- Show the video again with the sound and closed captioning turned on to allow students to clarify their ideas.
- *Optional:* Show one or more additional videos with the audio muted. Ask students to think about and discuss what is happening. Options include:
    - "Echinoderms: Sea Star Time-lapse: Eating Mussel" (2:47): shapeoflife.org/video/echinoderms-sea-star-time-lapse-eating-mussel
    - "Echinoderms: Sea Star Time-lapse: Pycnopodia Chases Snail" (2:19): shapeoflife.org/video/echinoderms-sea-star-time-lapse-pycnopodia-chases-snail
    - "Echinoderms: Urchin Time-lapse Eating Kelp" (3:25): shapeoflife.org/video/echinoderms-urchin-time-lapse-eating-kelp

Explore

2. Students explore art, videos, and more information about echinoderms. (12 – 15 min.)

- Pass out the "Artful Echinoderms" and "Echinoderms Fact Sheet" handouts and/or share links to the online versions. Invite students to review them with a partner or individually.
- Point out the additional videos listed at the end of the fact sheet and suggest that they view those, as well. Ask them to answer the questions on the "Artful" handouts.
- Tell students that a goal of their exploration into echinoderms is to gather information that will inspire them to create an original work of art inspired by echinoderms' amazing adaptations. Explain that they will be able to choose the medium of their choice, such as a clay model, detailed scientific illustration, poem, or story. For instance, they could focus on explaining with their art how the radial symmetry and other adaptions of echinoderms helps them to hunt.
- Tell them that exploring additional sources and videos could be helpful in their research.


Shape of Life

Artful Echinoderms

The painting below appeared in *The Natural History of Animals* by J.R. Ainsworth Davis, 1903 – 1905.

Think About It!

1. Can you identify the 4 types of echinoderms shown? Write the names and draw symbols for them below or in science notebooks.
2. What structures are common to all of these artful echinoderms?
3. What art and/or engineering designs do echinoderms inspire you to create?

The complete 8-volume series of books is at wellcomecollection.org/works/kb3gnmrq. This color plate is in Volume 2, page 454. The types of echinoderms are listed if you would like to check your answers.

"Artful Echinoderms" Lesson Plan 10 Shape of Life

The "Artful Echinoderms" handout found at the end of the lesson

3. Share more examples of echinoderm art. (1 – 4 min.)

- Show the students examples of some of the types of projects they could create, such as those created by other students or yourself.
- Supplement your available examples with online resources showing a range of the different types of echinoderms: brittle stars, crinoids, sea cucumbers, sea urchins, and sea stars/starfish. These could be in the mediums listed below or others, such as poems or stories.
- 3D models, such as:
    - Clay, painted starfish: youtu.be/ERC2umOqIH8
    - Origami starfish:
        - Simple, explained: youtube.com/watch?v=2Sr3qjKOjCY
        - Another design: youtu.be/MYyPp9Z7tf8
        - Another narrated example: youtube.com/watch?v=ABq4cKOihZc

        - Models with found/reused objects: youtu.be/IcR980B09VI
            - Colorful crinoid art, such as that shown here: montessoriinspiredco.com/f/echinoderms-sea-lilies-feather-stars-brittle-stars
            - Starfish external and internal anatomy: flickr.com/photos/ideonexus/3621359006
    - Paintings or diagrams, such as:
        - The tide pool painting shown on the "Artful Ecosystems" handout at the end of the lesson. Explain that students could incorporate other living and nonliving things from the echinoderms' ocean ecosystems into their artworks.
        - "Tree of Life" by Ray Troll. Zoom in on the Echinoderms branch: shapeoflife.org/sites/default/files/global/new-tree-of-life.pdf
    - Models illustrated with computer software, such as:
        - Sea urchin vascular system by Byron Inouye: manoa.hawaii.edu/exploringourfluidearth/media_colorbox/3376/media_original/en
        - "Arm and body regeneration in sea stars" by Byron Inouye: manoa.hawaii.edu/exploringourfluidearth/media_colorbox/3377/media_original/en

A section of the inspiring and educational "Tree of Life" painting by Ray Troll

    - Hand-drawn illustrations, such as:
        - "Brittle Star, Sea Urchins & Sand Dollars" by Ivy B., Nathan Hale Elem. School: nmsstellwagen.blob.core.windows.net/stellwagen-prod/media/art/2018/hm_b_2018_es.jpg
        - "Sea Cucumber Anatomy" by Claus Lunau: sciencephoto.com/media/1062497/view/sea-cucumber-anatomy-illustration
        - "Floyd the 'Noid" crinoid fossil: cedarvalleyrockclub.org/siteImages/Crinoids/Floyd.jpg
        - "How to Draw Starfish Step by Step: Easy Ocean Animals Drawing" by Art of Suryakantham: youtube.com/watch?v=c-m5vu8kkk0
    - Videos, such as:
        - "CreatureCast – Echinoderm Skin" (3:00) by Casey Dunn: vimeo.com/33985104
        - "Echinoderm Animation: Five-part Symmetry" (1:40): shapeoflife.org/video/echinoderm-animation-five-part-symmetry
        - "Echinoderm Animation: Sea Star Body Plan" (3:52): shapeoflife.org/video/echinoderm-animation-sea-star-body-plan
    - Poetry that includes echinoderms, such as:
        - "Starfish" by John Wedgwood Clarke: theguardian.com/books/booksblog/2012/dec/10/poem-starfish-john-wedgwood-clarke
        - "Sea Urchin" by J. Allyn Rosser: poetryfoundation.org/poetrymagazine/browse?contentId=12544
        - "Sanctuary" by Donika Kelly: poetryfoundation.org/poems/148205/sanctuary-5bc8e3630195d
- Fictional stories, such as:
    - "The Tale of the Starfish," adapted from "The Star Thrower" by Loren Eiseley: thestarfishchange.org/starfish-tale

- A longer adaptation by Joel Barker: starthrower.com/pages/the-star-thrower-story

  Stories can include one or more echinoderm species. For example, it could be an imaginative piece about a day in the life of an echinoderm. It could be set in a tidepool, kelp forest, coral reef, or another marine ecosystem. Students could include how the organism(s) are attempting to cope with a warming ocean and ocean acidification, and/or ways people are taking action to help the organisms.

- Nonfiction writing, such as "Sea Star Wasting Syndrome" by MARINe: marine.ucsc.edu/data-products/sea-star-wasting/index.html

4. Students select a type of echinoderm and artistic medium. (10 – 15 minutes or more)

   - Ask students to choose one or more types of echinoderm (e.g. brittle star, crinoid, sea cucumber, sea star, sea urchin) to incorporate into a type of art. Ask them to add labels and annotations to explain echinoderm structural and behavioral adaptations, including ways they are able to move, sense their world, catch food, and escape predators.

   - Tell students that they will be asked to present their art or writing to the class (or smaller groups).

   - Pass out an assessment rubric such as the "Artful Presentations Rubric" found at the end of the lesson. Explain to students that they should complete the "Your Score" column and turn it in to you when they are ready to present.

Explain

5. Students explain their art in presentations and/or writing. (15 – 40 min.)

   - Invite students to present their works to the class. Students could also explain the work in writing.

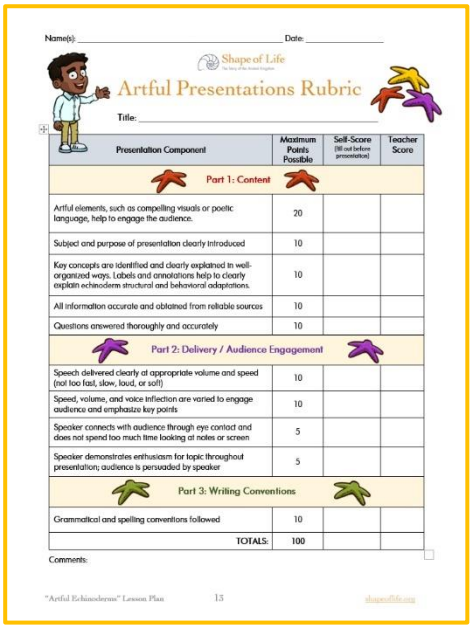
   - Help guide students to "use argument supported by evidence" that explains how their organisms "are a system of interacting subsystems composed of groups of cells" (NGSS). For instance, they can provide details about how interacting structural and behavior adaptations are used to help the organisms survive.

   - Invite the class to ask questions about the works, using them as springboards for interesting interactive discussions about echinoderms and the incredible adaptations that help them to survive in even the harshest environments, such as pounding surf and hydrothermal vents in the deep ocean.

   - Ask the class to share any other key characteristics of echinoderms that weren't already mentioned in the discussion of the art. They can refer to their notes and the fact sheet for ideas.

   - *Optional:*

     - Display works on classroom and/or school walls or at community buildings. This will celebrate student learning and inspire others to care about echinoderms. Students can create cards that list the titles of their works, their names and grades, and descriptions of the art.



Name(s): _____ Date: _____

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Artful Presentations Rubric

Title: _____

Presentation Component	Maximum Points Possible	Self-Score (fill out before presentation)	Teacher Score
Part 1: Content			
Artful elements, such as compelling visuals or poetic language, help to engage the audience.	20		
Subject and purpose of presentation clearly introduced	10		
Key concepts are identified and clearly explained in well-organized ways. Labels and annotations help to clearly explain echinoderm structural and behavioral adaptations.	10		
All information accurate and obtained from reliable sources	10		
Questions answered thoroughly and accurately	10		
Part 2: Delivery / Audience Engagement			
Speech delivered clearly at appropriate volume and speed (not too fast, slow, loud, or soft)	10		
Speed, volume, and voice inflection are varied to engage audience and emphasize key points	10		
Speaker connects with audience through eye contact and does not spend too much time looking at notes or screen	5		
Speaker demonstrates enthusiasm for topic throughout presentation; audience is persuaded by speaker	5		
Part 3: Writing Conventions			
Grammatical and spelling conventions followed	10		
TOTALS:	100		

Comments:

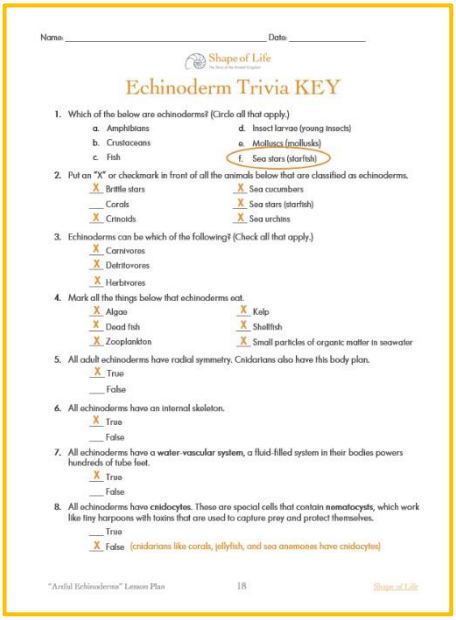
"Artful Echinoderms" Lesson Plan 13 shapeoflife.org

The "Artful Presentations Rubric" found at the end of the lesson

- Do a gallery walk of student art. Invite students to circulate and ask questions about each other's artworks.

6. Closing discussion / reflection (5 – 7 min.)

- Pass out the "Echinoderm Trivia" activity and ask students to complete it on their own. After a couple of minutes, discuss their answers, asking students to change any that they answered incorrectly.
- Discuss the "Artful Echinoderms" handout. Point to each of the four types shown, one at a time, and ask students to try to say the names on the count of three (from top): brittle star, sea urchin, sea star (starfish), and sea cucumber. Ask students to share details about the five shared adaptations of echinoderms that they learned from the fact sheet, videos, or other sources:
  - Five-part radial symmetry
  - An internal skeleton
  - A water-vascular system
  - A nerve ring
  - An eversible stomach
- Close with a discussion of the characteristics of echinoderms that students found the most interesting and any they would like to have themselves.
- Ask students to reflect on what they learned in the lesson in writing in science notebooks or via a discussion in your learning management system (LMS), in an "exit ticket" that they will hand to you as they leave the class, or in an email message to you.



Name: _____ Date: _____

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Echinoderm Trivia KEY

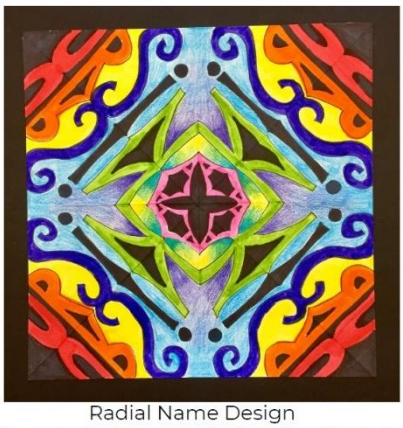
1. Which of the below are echinoderms? (Circle all that apply.)
   a. Amphibians
   b. Crustaceans
   c. Fish
   d. Insect larvae (young insects)
   e. Molluscs (mollusks)
   f. Sea stars (starfish)
2. Put an "X" or checkmark in front of all the animals below that are classified as echinoderms.
   X Brittle stars
   ___ Corals
   X Crinoids
   X Sea cucumbers
   X Sea stars (starfish)
   X Sea urchins
3. Echinoderms can be which of the following? (Check all that apply.)
   X Carnivores
   X Detritivores
   X Herbivores
4. Mark all the things below that echinoderms eat.
   X Algae
   X Dead fish
   X Zooplankton
   X Kelp
   X Shellfish
   X Small particles of organic matter in seawater
5. All adult echinoderms have radial symmetry. Cnidarians also have this body plan.
   X True
   ___ False
6. All echinoderms have an internal skeleton.
   X True
   ___ False
7. All echinoderms have a **water-vascular system**, a fluid-filled system in their bodies powers hundreds of tube feet.
   X True
   ___ False
8. All echinoderms have **cnidocytes**. These are special cells that contain **nematocysts**, which work like tiny harpoons with toxins that are used to capture prey and protect themselves.
   ___ True
   X False (cnidarians like corals, jellyfish, and sea anemones have cnidocytes)

"Artful Echinoderms" Lesson Plan 18 Shape of Life

An "Echinoderm Trivia Key" can also be found at the end of the lesson

Extend / Enrich

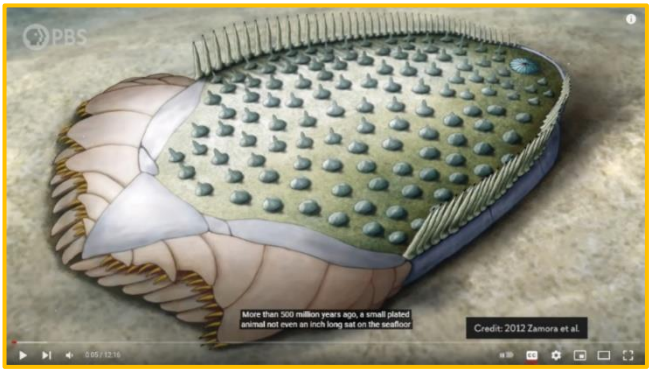
- Guide students through an activity about radial symmetry. (15 minutes or more)
    - A lesson by award-winning art teacher Ursina Amsler that uses folded paper is explained here: amslerartroom.wordpress.com/remote-learning/radial-symmetry-name-designs
    - "Math & Mandalas" is a lesson from Let's Talk Science that uses a compass as an option to create radially symmetrical geometric patterns: letstalkscience.ca/educational-resources/lessons/math-mandalas
    - Creating **mandalas** is a great activity with clear aesthetic principles, cultural connections, and even established benefits to emotional regulation and introspection. A thematic connection to emphasize and explore is how mandalas contain a unit of information that repeats multiple times, rotated around the center point. If you create a mandala on a sheet of paper and cut it through the center, each piece will still contain that essential unit of information. You could give this fragment to a friend, and they could use it to regenerate a full mandala just like the original one, not unlike how an echinoderm can regrow arms and even whole bodies from one part!
    - Try to help students see the connections between the radial symmetry in your designs and the **five-part radial symmetry** of echinoderms. Ask them to think about and discuss how drawing mandalas can help us understand the benefits of a radial body plan. For example, the property of being able to regenerate a whole from fragments benefits echinoderms. Many species can lose a leg and regrow it, and many others are able to reproduce simply by splitting into pieces that regenerate into multiple individuals. The radial symmetry of their body plan supports this: being made of multiple repeated instances of the essential unit makes it possible to survive and reproduce even when damaged or fragmented, because the other body parts provide the exact same function. By creating mandalas, students begin to understand this property in an embodied way as they continuously refer back to the information contained in the essential unit in order to create the other parts of the whole. In this sense, the art inquiry deepens the understanding of the science inquiry, by giving first-hand insights into the benefits of this form of organization. In turn, observing the echinoderms and analyzing their structures can support the creation of the mandala, by offering a set of colors, shapes, and patterns and even symbolic meaning that can inform creative choices around the design.



A free "Radial Name Design" packet is available in both student and instructor versions from Ursina Amsler

- Explore echinoderm evolution. (12 minutes or more)

    Invite students to learn more about the fascinating evolutionary history of echinoderms by watching "How the Starfish Got Its Arms" from PBS Eons: youtu.be/5GdkQJN1XZs.

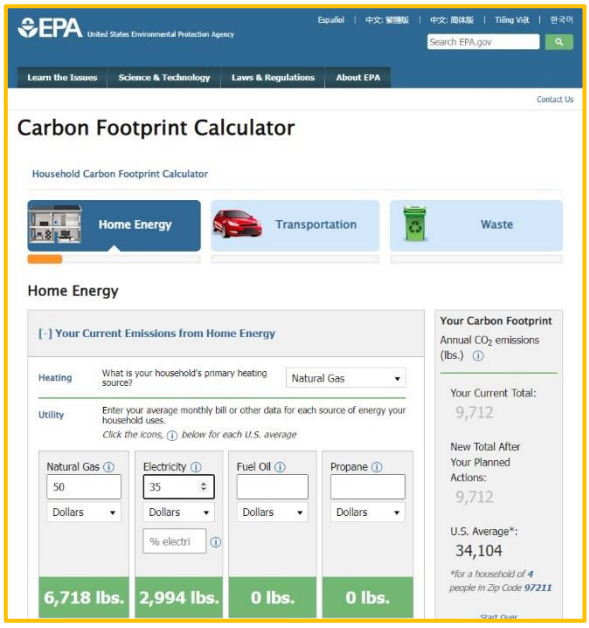


- Students dive deeper into echinoderm research. (5 – 20 min.)
    - Students can learn more about different species' lifestyles, relatives, and biology by watching other Shape of Life videos and/or doing additional research.
    - Students can present their findings about a specific species to the class. Provide a rubric so students know how they will be assessed, such as the one at the end of the "Science in Action!" lesson: shapeoflife.org/lesson-plan/sol/science-action.
- Conduct a field study to observe live echinoderms. (Will vary)
    - Take students on a field study to a tidepool, aquarium, or other area where students can observe live echinoderms and their ecosystems firsthand.

Students sort marine organisms during a BioBlitz with the Natural History Museum of Los Angeles County.
National Park Service: flickr.com/photos/santamonicamtns/26968299982

    - Be sure students are prepared with appropriate clothing, safety rules, ways to avoid damaging the ecosystem, etc.
    - Ask students to bring field journals to record notes, illustrations, and questions about what they observe.
    - Photographs can also be taken to help identify species and create detailed scientific illustrations.
- Discuss current events related to echinoderms and research being conducted into the health of their populations and ecosystems. (1 – 20 min.)
    - Find news highlighting scientific findings or questions about echinoderms. This will make the activities and discussions more relevant and personal to the students. For instance, Sea Star Wasting Syndrome has been a catastrophic phenomenon observed along the West Coast, as highlighted in:
        - This article from the National Park Service: nps.gov/im/swan/ssws.htm
        - This Shape of Life news article: shapeoflife.org/news/general-news/2021/03/01/sea-star-wasting-disease
    - Impacts of the climate crisis and ocean acidification on echinoderms would also stimulate thinking and discussion.

- If environmental problems are discussed, we recommend doing it quickly and spending more time highlighting positive steps humans are taking to mitigate the impacts, such as reducing carbon emissions and restoring ecosystems.
- Ask students to share ways they can take action locally, such as planting trees and other native plants along riparian areas and organizing walk- and bike-to-school campaigns, which will help them reduce local CO2 emissions and feel empowered to make a difference. Their actions will also inspire others to act and be more hopeful about the future.
- Invite students to use and share a carbon footprint calculator to help lower emissions. One good option is at www3.epa.gov/carbon-footprint-calculator.



Invite students to calculate their carbon footprints and take action to reduce their emissions that are negatively impacting echinoderms and other marine life.

- Setup learning/exploration centers and offer students a choice of activities.

  Classroom centers can be setup with other activities related to echinoderms and their adaptations, such as those listed above. This would provide more opportunity for student choice and differentiated learning experiences to maximize intrinsic motivation, engagement, and learning.

Evaluate

7. Evaluate students presentations of their artistic works and/or research projects.
   - Provide a rubric such as the one at the end of the lesson so students know how they will be assessed.
   - A document camera and/or data projector can be used to better present the art.
   - Help guide students to "use argument supported by evidence" that explains how their organisms "are a system of interacting subsystems composed of groups of cells" (NGSS). For instance, they can provide details about how interacting structural and behavior adaptations are used to help the organisms survive.
   - Students could also be asked to create a larger version of their diagram on poster board with more detail, color, etc. These can include clear annotations which could also serve as notes if you would like students to present their diagrams to the class.
   - Completed projects can also be displayed on classroom and/or school walls.
8. Review completed art projects, science notebooks, and handouts.
   - Review student art, labels, annotations, and handouts.
   - Check that they have explained echinoderm structural and behavioral adaptations with their art, including ways they are able to catch food and escape predators.

Expand Knowledge + Skills

Related Lesson Plans / Resources

- Carsten, L.D. et al. "Fostering a STEAM Mindset Across Learning Settings." NSTA: nsta.org/connected-science-learning/connected-science-learning-october-december-2019/fostering-steam-mindset
- "Modeling Evolutionary Relationships with Trees" lesson plan. Shape of Life: shapeoflife.org/lesson-plan/sol/modeling-evolutionary-relationships-trees
- "Radial Symmetry..." presentation and examples by Christy Sullivan: blendspace.com/lessons/EyC13Z3FS4ujkA/6th-radial-symmetry-color-radial-name-mandala
- "Radial Symmetry: Let's Make a Design" by Lynn Bernstein, featuring an amazing puffer fish that also creates radial symmetry designs: youtu.be/JrEq0pkZ2q8
- "Science in Action!" lesson plan. Shape of Life: shapeoflife.org/lesson-plan/sol/science-action

Echinoderms

- "Radically Radial: The Sea Star." Shape of Life: shapeoflife.org/news/featured-creature/2019/03/19/radically-radial-sea-star
- "Phylum Echinodermata." Exploring Our Fluid Earth: Teaching Science as Inquiry (TSI). Univ. of Hawai'i: manoa.hawaii.edu/exploringourfluidearth/biological/invertebrates/phylum-echinodermata
- "Echinoderms." CK-12: flexbooks.ck12.org/cbook/ck-12-biology-flexbook-2.0/section/11.12/primary/lesson/echinoderms-bio

Standards and Three-Dimensional Learning

- Next Generation Science Standards, including a link to the *Framework for K-12 Science Education* to which this lesson was aligned: nextgenscience.org/framework-k%E2%80%9312-science-education
- "Three Dimensional Learning." Next Generation Science Standards: nextgenscience.org/three-dimensions
- Common Core State Standards and links to the complete documents: corestandards.org

Appreciation + Thanks

Thank you for using Shape of Life resources and helping to inspire the next generation of thinkers and scientists! We also greatly appreciate all you do and welcome your questions or comments.

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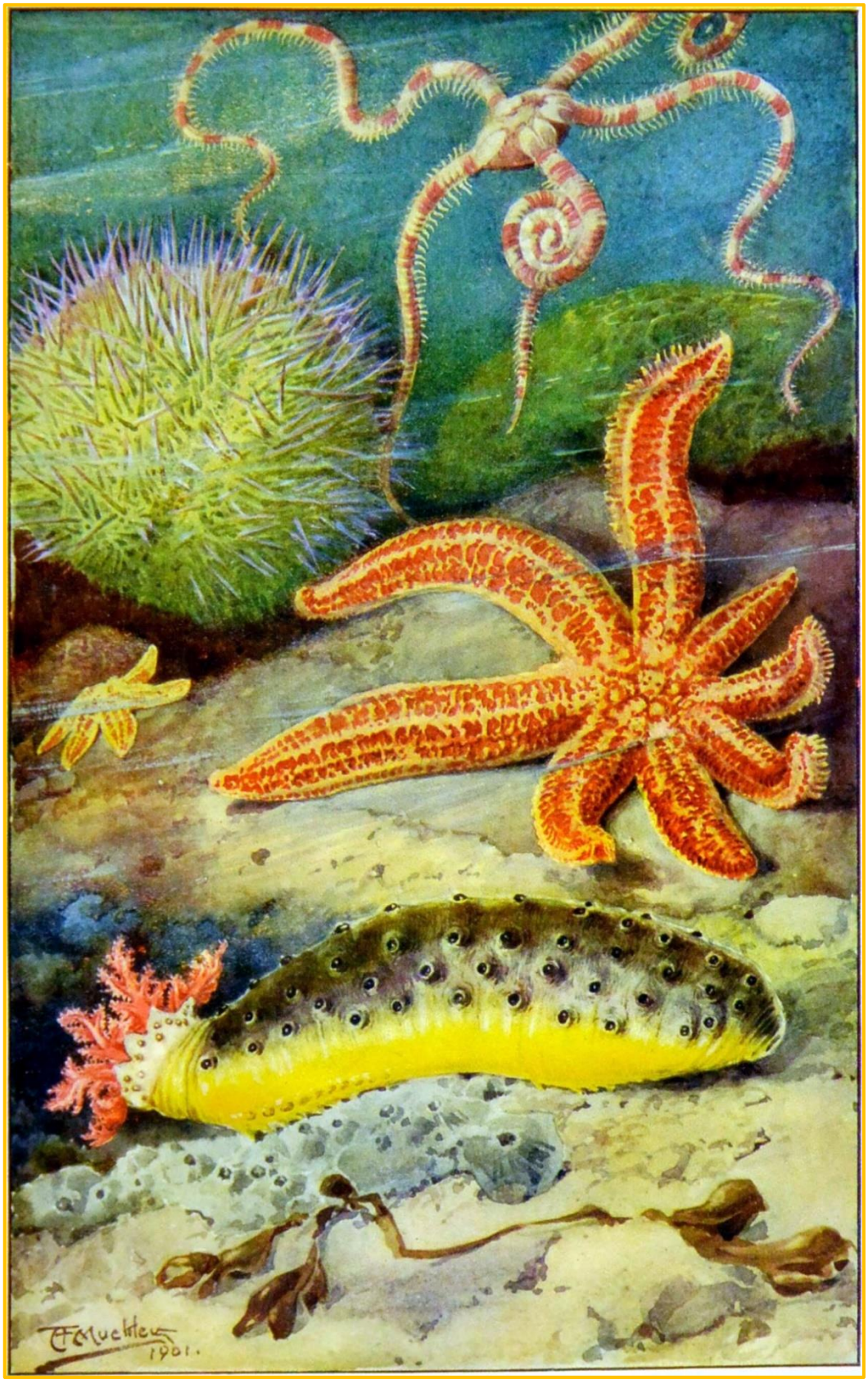
Edited by Nancy Burnett and Natasha Fraley
Shape of Life

Artful Echinoderms

The painting below appeared in *The Natural History of Animals* by J.R. Ainsworth Davis, 1903 – 1905.



Think About It!

1. Can you identify the 4 types of echinoderms shown? Write the names and draw symbols for them below or in science notebooks.

2. What structures are common to all of these artful echinoderms?

3. What art and/or engineering designs do echinoderms inspire you to create?

The complete 8-volume series of books is at wellcomecollection.org/works/kb3pmra.

This color plate is in Volume 2, page 454. The types of echinoderms are listed if you would like to check your answers.

Artful Ecosystems

This painting appeared in *The Natural History of Animals* by J.R. Ainsworth Davis, 1903 – 1905.

Think About It!

1. Which organisms shown have radial symmetry? Write their names and/or illustrate them below or in science notebooks.

2. Draw a circle around each organism that is classified as an echinoderms.

3. What art and/or engineering designs do tide pools and other ocean ecosystems inspire you to create? Record your ideas with words and pictures below and/or in science notebooks.

Name: _____ Date: _____

Shape of Life
The Story of the Animal Kingdom

Echinoderm Trivia

1. Which of the below are echinoderms? (Circle all that apply.)
   a. Amphibians
   b. Crustaceans
   c. Fish
   d. Insect larvae (young insects)
   e. Molluscs (mollusks)
   f. Sea stars (starfish)

2. Put an "X" or checkmark in front of all the animals below that are classified as echinoderms.
   ___ Brittle stars
   ___ Corals
   ___ Crinoids
   ___ Sea cucumbers
   ___ Sea stars (starfish)
   ___ Sea urchins

3. Echinoderms can be which of the following? (Check all that apply.)
   ___ Carnivores
   ___ Detritovores
   ___ Herbivores

4. Mark all the things below that echinoderms eat.
   ___ Algae
   ___ Dead fish
   ___ Zooplankton
   ___ Kelp
   ___ Shellfish
   ___ Small particles of organic matter in seawater

5. All adult echinoderms have radial symmetry.
   ___ True
   ___ False

6. All echinoderms have an internal skeleton.
   ___ True
   ___ False

7. All echinoderms have a **water-vascular system**, a fluid-filled system in their bodies powers hundreds of tube feet.
   ___ True
   ___ False

8. All echinoderms have **cnidocytes**. These are special cells that contain **nematocysts**, which work like tiny harpoons with toxins that are used to capture prey and protect themselves.
   ___ True
   ___ False

Name: _____ Date: _____

Shape of Life
The Story of the Animal Kingdom

Echinoderm Trivia KEY

1. Which of the below are echinoderms? (Circle all that apply.)
   - a. Amphibians
   - b. Crustaceans
   - c. Fish
   - d. Insect larvae (young insects)
   - e. Molluscs (mollusks)
   - f. Sea stars (starfish)

2. Put an "X" or checkmark in front of all the animals below that are classified as echinoderms.
   - _X_ Brittle stars
   - ___ Corals
   - _X_ Crinoids
   - _X_ Sea cucumbers
   - _X_ Sea stars (starfish)
   - _X_ Sea urchins

3. Echinoderms can be which of the following? (Check all that apply.)
   - _X_ Carnivores
   - _X_ Detritovores
   - _X_ Herbivores

4. Mark all the things below that echinoderms eat.
   - _X_ Algae
   - _X_ Dead fish
   - _X_ Zooplankton
   - _X_ Kelp
   - _X_ Shellfish
   - _X_ Small particles of organic matter in seawater

5. All adult echinoderms have radial symmetry.
   - _X_ True
   - ___ False

6. All echinoderms have an internal skeleton.
   - _X_ True
   - ___ False

7. All echinoderms have a **water-vascular system**, a fluid-filled system in their bodies powers hundreds of tube feet.
   - _X_ True
   - ___ False

8. All echinoderms have **cnidocytes**. These are special cells that contain **nematocysts**, which work like tiny harpoons with toxins that are used to capture prey and protect themselves.
   - ___ True
   - _X_ False (cnidarians like corals, jellyfish, and sea anemones have cnidocytes)

Name(s): _____ Date: _____

Shape of Life
The Story of the Animal Kingdom

Artful Presentations Rubric

Title: _____

Presentation Component	Maximum Points Possible	Self-Score (fill out before presentation)	Teacher Score
Part 1: Content			
Artful elements, such as compelling visuals or poetic language, help to engage the audience.	20		
Subject and purpose of presentation clearly introduced	10		
Key concepts are identified and clearly explained in well-organized ways. Labels and annotations help to clearly explain echinoderm structural and behavioral adaptations.	10		
All information accurate and obtained from reliable sources	10		
Questions answered thoroughly and accurately	10		
Part 2: Delivery / Audience Engagement			
Speech delivered clearly at appropriate volume and speed (not too fast, slow, loud, or soft)	10		
Speed, volume, and voice inflection are varied to engage audience and emphasize key points	10		
Speaker connects with audience through eye contact and does not spend too much time looking at notes or screen	5		
Speaker demonstrates enthusiasm for topic throughout presentation; audience is persuaded by speaker	5		
Part 3: Writing Conventions			
Grammatical and spelling conventions followed	10		
TOTALS:	**100**		

Comments:

Artful Ecosystems KEY

This painting appeared in *The Natural History of Animals* by J.R. Ainsworth Davis, 1903 – 1905.

Think About It!

1. Which organisms shown have radial symmetry? Write their names and/or illustrate them below or in science notebooks.
   Sea anemones and starfish (sea stars)

2. Draw a circle around each organism that is classified as an echinoderm.

3. What art and/or engineering designs do tide pools and other ocean ecosystems inspire you to create? Record your ideas with words and pictures below and/or in science notebooks.