Shape of Life
The Story of the Animal Kingdom

Annelid Adaptations + Art

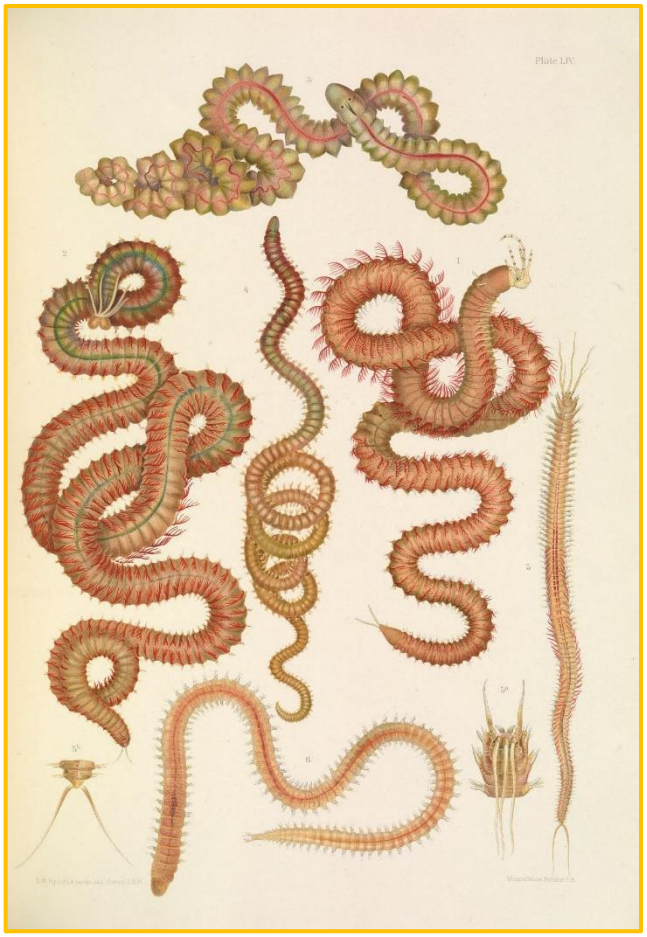
Engaging Students with Annelid Phenomena, Adaptations, and Art

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 annelid behaviors using a Shape of Life video with the audio turned off. They try to figure out what the phenomenon (the behavior) is, how it might help the organism survive, and how it might impact the environment. Working with a partner, they make hypotheses about what they are observing and the organisms' adaptations that allow it to perform the behavior. They then explore how a key feature of both annelids and some art is repetition and how repeating patterns have benefits for both annelids and artists. They create artworks inspired by annelids and present them to the class, using the different mediums to explain annelid adaptions. Extend / Enrich activities are listed at the end of the lesson to help engage all learners.

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 annelid adaptations orally, with art, and in writing.



Artful annelids from "A Monograph of British Marine Annelids," 1873: biodiversitylibrary.org/page/38533306#page/323

Subjects

Science, Reading, Writing, and Art

Grades

Adaptable for 3 – 12

Time

40 – 90 minutes or more

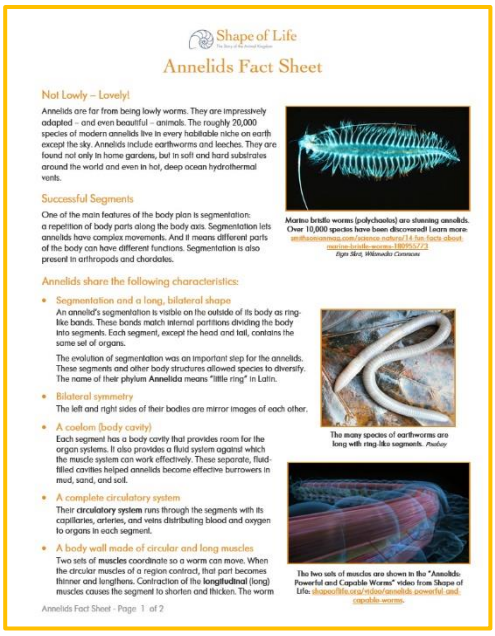
Vocabulary

Annelid, biological evolution, bristle worms (polychaetes), bilateral symmetry, burrowing annelids, circulatory system, coelom (body cavity), earthworms, gills, gut, leeches, longitudinal muscles, model, phenomenon/a, repetition, sediment, segmentation, setae, systems, spaghetti worms, tubeworms

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 "Annelids Fact Sheet" for background information about the phylum. The printable handout and other factsheets are available at shapeoflife.org/factsheets.


Shape of Life

Annelids Fact Sheet

Not Lowly – Lovely!

Annelids are far from being lowly worms. They are impressively adapted – and even beautiful – animals. The roughly 20,000 species of modern annelids live in every habitable niche on earth except the sky. Annelids include earthworms and leeches. They are found not only in home gardens, but in soft and hard substrates around the world and even in hot, deep ocean hydrothermal vents.

Successful Segments

One of the main features of the body plan is segmentation: a repetition of body parts along the body axis. Segmentation lets annelids have complex movements. And it means different parts of the body can have different functions. Segmentation is also present in arthropods and chordates.

Marine bristle worms (polychaetes) are stunning annelids. Over 10,000 species have been discovered! Learn more: earthsendgroup.com/science-nature/14-fun-facts-about-marine-bristle-worms-1809553723

Ryan Bird, Wikimedia Commons

Annelids share the following characteristics:

- Segmentation and a long, bilateral shape

An annelid's segmentation is visible on the outside of its body as ring-like bands. These bands match internal partitions dividing the body into segments. Each segment, except the head and tail, contains the same set of organs.

The evolution of segmentation was an important step for the annelids. These segments and other body structures allowed species to diversify. The name of their phylum Annelida means "little ring" in Latin.

- Bilateral symmetry

The left and right sides of their bodies are mirror images of each other.

- A coelom (body cavity)

Each segment has a body cavity that provides room for the organ systems. It also provides a fluid system against which the muscle system can work effectively. These separate, fluid-filled cavities helped annelids become effective burrowers in mud, sand, and soil.

The many species of earthworms are long with ring-like segments. Pixabay

- A complete circulatory system

Their **circulatory system** runs through the segments with its capillaries, arteries, and veins distributing blood and oxygen to organs in each segment.

- A body wall made of circular and long muscles

Two sets of **muscles** coordinate so a worm can move. When the circular muscles of a region contract, that part becomes thinner and lengthens. Contraction of the **longitudinal** (long) muscles causes the segment to shorten and thicken. The worm

The two sets of muscles are shown in the "Annelids: Powerful and Capable Worms" video from Shape of Life. shapeoflife.org/video/annelids-powerful-and-capable-worms

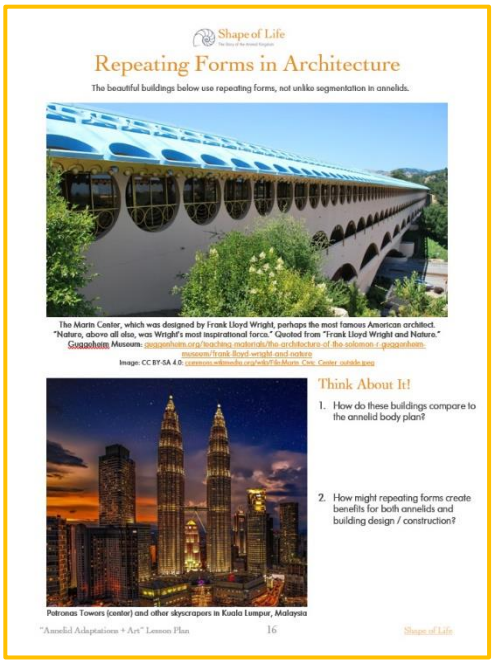
Annelids Fact Sheet - Page 1 of 2

Repetition in Annelids + Art

A key feature of both annelids and some art is repetition. The annelid body plan uses **segmentation**, which allows the animals to grow and develop by repeating a set of features in each segment, such as circular muscles. In a similar way, art forms such as music, dance, and architecture can use repeating forms to simplify how they are constructed and create pleasing compositions that follow themes. Examples include simple, repeating melodies, rhythmic dance steps, and the stacked floors of high-rise buildings. Repeating patterns like these have benefits for both annelids and artists, including efficiency with creating complete organisms and human-produced art / structures, not to mention the beauty and joy that we can experience from repeating, familiar patterns. In both art and diverse annelids, repetition adds a rhythm that can have variation without losing the rhythm and overall unity of the forms.

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. For example, this lesson asks students to explore the use of repeating forms to create a work of art. 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. 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.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Repeating Forms in Architecture

The beautiful buildings below use repeating forms, not unlike segmentation in annelids.

The Marin Center, which was designed by Frank Lloyd Wright, perhaps the most famous American architect. "Nature, above all else, was Wright's most inspirational force." Quoted from "Frank Lloyd Wright and Nature." Guggenheim Museum. guggenheim.org/teaching-materials/the-architecture-of-the-solomon-r-guggenheim-museum/frank-lloyd-wright-and-nature

Image: CC BY-SA 4.0. commons.wikimedia.org/wiki/File:Marin_Civic_Center_outside.jpeg

Think About It!

1. How do these buildings compare to the annelid body plan?
2. How might repeating forms create benefits for both annelids and building design / construction?

Petronas Towers (center) and other skyscrapers in Kuala Lumpur, Malaysia

"Annelid Adaptations + Art" Lesson Plan 16 Shape of Life

The "Repeating Forms in Architecture" handout found at the end of the lesson

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 a three-dimensional (3D) model of an annelid or building of the students' choice that uses segmentation and repeating forms can help them understand how both annelids and architecture incorporate repetition, with multiple benefits for each. A thematic connection to emphasize and explore is how both annelids and buildings contain a unit of information that repeats multiple times. The repeated **segmentation** of the annelid body plan could create a complete annelid, just like repeating structures such as pillars, windows, and rooms, can create the complete floor of building, and repeating the floors can create a skyscraper. The basic unit is repeated with added artistic elements, or in the case of annelids, **setae** (hair-like structures), gills and other external and internal structures.

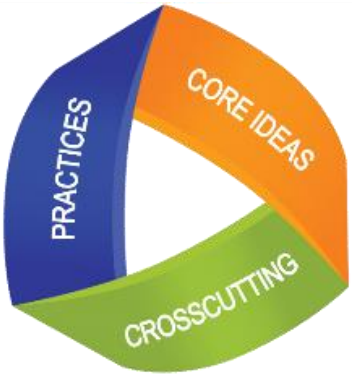
Artful annelids from "A Monograph of British Marine Annelids," 1873: biodiversitylibrary.org/page/37824157#page/267

If you create symmetrical art, try to help students see the connections between the science and art, such as between the bilateral symmetry in your designs and that of annelids and most other animals on earth. (Only sponges do not have either bilateral or radial symmetry.) Ask them to think about and discuss how drawing symmetrical designs that incorporate segmentation can help us understand the benefits of segmentation and a bilateral body plan. By working through a tightly scaffolded exemplar, such as the 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.

Phenomena-driven Inquiry

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.

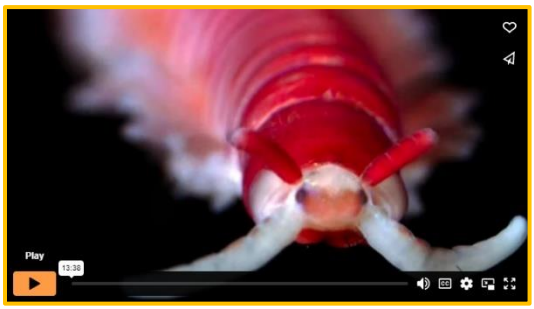


The 3Ds of NGSS: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas

Materials + Preparation

- One or more short Shape of Life videos showing annelids in action, such as:
  - "Abarenicola, Burrowing Worm" (2:38): shapeoflife.org/video/annelids-abarenicola-burrowing-worm

  - "Annelids: Powerful and Capable Worms" (13:38): shapeoflife.org/video/annelids-powerful-and-capable-worms



- Copies of the "Annelids Fact Sheet" from Shape of Life for each student found at shapeoflife.org/factsheets
- Science notebook and pencil or pen for each student
- Computer with Internet connection and data projector
- Whiteboard or chart paper and markers

- Copies of the "Artful Annelids" and "Repeating Forms in Architecture" handouts found at the end of the lesson for each student or pair of students
- *Optional:* Copies for each student of the "I Notice, I Wonder, It Reminds Me Of" handout found at the end of the lesson
- *Optional:* Prepare to show one or more additional videos during the Explain section when discussing concepts with students. Options include:
    - "Annelid Animation: Body Plan" (1:06): shapeoflife.org/video/annelid-animation-body-plan
    - "Annelids: Terrebellid, Spaghetti Worm" (1:32): shapeoflife.org/video/annelids-terrebellid-spaghetti-worm
    - "Bilateral Body Plan" (2:49): shapeoflife.org/video/bilateral-body-plan
    - "Damhnait McHugh, Ecologist: Annelid Ecology" (6:27): shapeoflife.org/video/damhnait-mchugh-ecologist-annelid-ecology
    - "Lumbricus, Earthworm" (3:28): shapeoflife.org/video/annelids-lumbricus-earthworm
    - "Leeches" (3:16): shapeoflife.org/video/annelids-leeches

Teaching Suggestions in the 5E Model

Engage

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

    - Pass copies of the "I Notice, I Wonder, It Reminds Me Of" graphic organizer found at the end of lesson, one for each student, or ask them to create a similar organizer in science notebooks.
    - Show students a short Shape of Life video about an annelid behavior. Mute the audio and turn off closed captioning (if applicable). One engaging option is "Abarenicola, Burrowing Worm" (starting at 1:07, ending at 2:30): shapeoflife.org/video/annelids-abarenicola-burrowing-worm
    - 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 the organizer, including anything they may have already learned about creatures like these.
    - After a minute, invite students to turn to a neighbor to discuss their ideas. Ask them to record additional brainstormed ideas on the organizers and/or in science notebooks, such as how, exactly, the creature is able to move and how its burrowing might impact the environment.
    - 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 complete video with the sound and closed captioning turned on to allow students to clarify their ideas.


Name(s): _____ Date: _____

Shape of Life

I Notice, I Wonder, It Reminds Me Of

This organizer can help you record your observations, thoughts, and ideas.

Things I Notice	What I Wonder About ? ? ?	Things it Reminds Me Of

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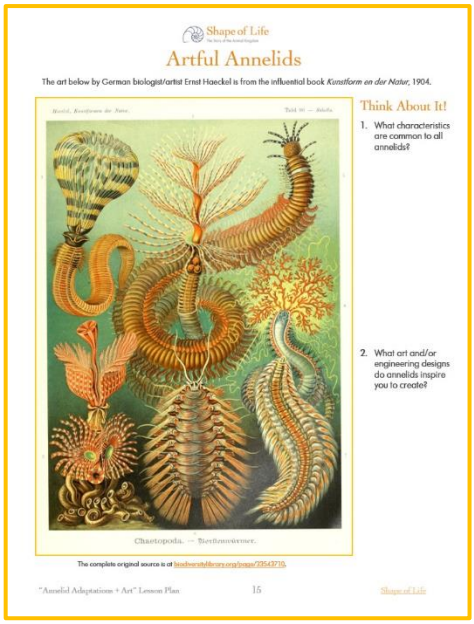
The "I Notice, I Wonder, It Reminds Me Of" graphic organizer

Explore

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

- Pass out the "Artful Annelids" and "Annelids Fact Sheet" handouts 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 Annelids" handout.
- Tell students that a goal of their exploration into annelids is to gather information that will inspire them to create an original work of art inspired by annelids' 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 segmentation and other adaptations of annelids help them to survive, grow, and reproduce. And the repeating body plan provides annelids with units that have different functions for different lifestyles. The various adaptations, variations on the simple, repeating theme, allow annelids to survive in diverse habitats.
- Tell them that exploring additional sources and videos could be helpful in their research.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Artful Annelids

The art below by German biologist/artist Ernst Haeckel is from the influential book *Kunstform en der Natur*, 1904.

Think About It!

1. What characteristics are common to all annelids?

2. What art and/or engineering designs do annelids inspire you to create?

Chaetopoda. — Borstenwürmer.

The complete original source is at biodiversitylibrary.org/page/23543715.

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

3. Students explore the connection between repeating forms in annelids and architecture. (10 – 15 min.)

- Pass out the "Repeating Forms in Architecture" handout to students (or pairs of students). Ask them to answer the questions and create a repeating model of their own: either a type of annelid with segmentation or building with repeating forms, such as columns, windows, and / or rooms. They might create 2D models on paper and / or 3D models if you provide clay, Play-Doh, or other materials.
- Show students some examples of completed 3D models, such as those made by yourself, other students, or the clay earthworm models shown here: montessorifromtheheart.com/2018/07/06/earthworms-unit-study-zoology-play-dough-sensory-bin-preschool-kids-activities-homeschool
- Supplement your available examples with other online resources showing a range of different types of annelids. These could be in the mediums listed below or others.
- Photography / videography:
  - *Scoletoma fragilis* by E.A. Lazo-Wasem: wikidata.org/wiki/Q61612413#/media/File:Scoletoma_fragilis_(YPM_IZ_098632).jpeg
  - Imagery shown in Shape of Life videos and others, such as "The Wonderful World of Deep Sea Worms": youtu.be/oNjcBk4C4kQ

- Paintings or diagrams, such as:
    - The art shown on the "Artful Annelids" handout at the end of the lesson. Explain that students could incorporate other living and nonliving things from the annelids' ecosystems into their artworks.
    - "Tree of Life" by Ray Troll. Zoom in on the annelids branch: shapeoflife.org/sites/default/files/global/new-tree-of-life.pdf
- Models illustrated with computer software, such as:
    - Annelid bodies (diagrams shown lower on page): bodell.mtchs.org/OnlineBio/BIOCD/text/chapter23/concept23.6.html
    - "Contraction of Muscles and Movement in an Earthworm" by Byron Inouye: manoa.hawaii.edu/exploringourfluidearth/sites/default/files/Fig3.47-Contraction_of_Muscles.png
    - "Earthworm Head" by KDS4444: upload.wikimedia.org/wikipedia/commons/8/8f/Earthworm_head.svg
    - "Internal Anatomy of a Segment of an Annelid": en.wikipedia.org/wiki/Annelid#/media/File:Annelid_redone_w_white_background.svg
- Hand-drawn illustrations, such as:
    - Annelid illustrations by Robert Macintosh and Ada H. Walker: biodiversitylibrary.org/page/37824157#page/267
    - "How to Draw Pheretima || Earthworm" by SmhR animal science: youtu.be/M6RGIFTWMS4
    - *Lumbricus fragilis (Scoletoma fragilis):* garystockbridge617.getarchive.net/media/lumbricus-fragilis-print-iconographia-zoologica-special-collections-university-3b65cc
- Videos, such as Shape of Life videos listed on the "Annelids Fact Sheet" and these created by college students, which could inspire your students to create their own artful videos:
    - "CreatureCast – Dracunculus" (1:59): creaturecast.org/archives/2814-creaturecast-dracunculus
    - "CreatureCast – Marine Worms" (6:24): creaturecast.org/archives/918-creaturecast-episode-4
    - "CreatureCast – Sex in Spoonworms" (2:15): creaturecast.org/archives/category/annelids
- Artful, rare fossils of annelids, like *Esconites zelus:* flickr.com/photos/jsjgeology/34765577355
- Poetry that includes annelids, such as:
    - "Worms" by Carl Dennis: poetryfoundation.org/poetrymagazine/poems/41833/worms-56d22025af8d8
    - "The Worm" by Ralph Bergengren: poetryfoundation.org/poems/46928/the-worm
- Fictional stories, such as "The Day the Worms Moved In" by Marlane Kennedy: storyworks.scholastic.com/issues/2019-20/100119/the-day-the-worms-moved-in.html

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

- Nonfiction writing, such as "Ancient Peperami Had A Surprisingly Complex Body For A 515-Million-Year-Old Worm" by Rachael Funnell: iflscience.com/ancient-peperami-had-a-surprisingly-complex-body-for-a-515-million-year-old-worm-67338
- "Ancient Sea-Worm Mystery Solved by Student After 50 Years in "Wastebasket": scitechdaily.com/ancient-sea-worm-mystery-solved-by-student-after-50-years-in-wastebasket

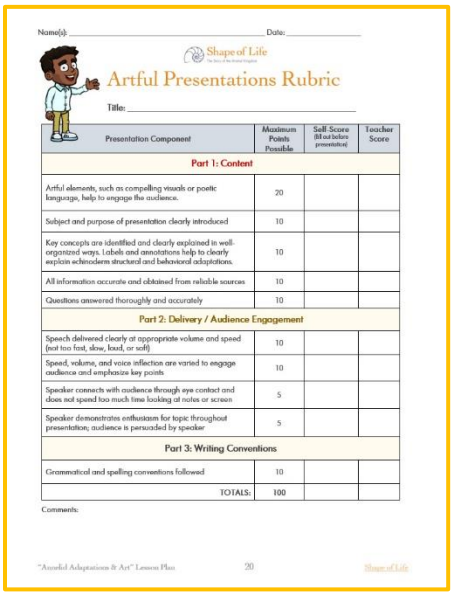
Explain

4. Students select a type of annelid and artistic medium to explain about it. (10 – 15 minutes)

- Ask students to choose one or more types of annelid to incorporate into a type of art. Ask them to explain annelid structural and behavioral adaptations, including ways they use repeating forms and ways they are able to move, sense their world, catch food, and escape predators. They should use labels and annotations or another method to explain the physical and behavioral adaptations.
- 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.

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

- Invite students to present their models or annelids or buildings or other artworks 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 segmentation and 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 annelids and the incredible adaptations that help them to survive in even the harshest environments, such as hydrothermal vents in the deep ocean, underground environments, and in digestive systems of animals.
- Ask the class to share any other key characteristics of annelids 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 annelids. Students can create cards that list the titles of their works, their names and grades, and descriptions of the art.



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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:

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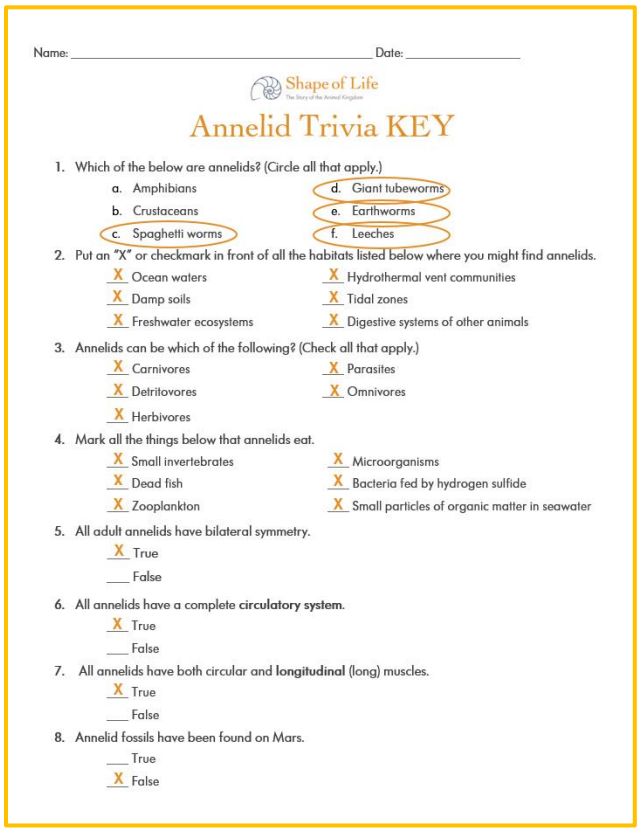
The "Artful Presentations Rubric" found at the end of the lesson

- 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.)

- Ask, "How might repeating forms create benefits for both annelids and art like architecture and building design/construction?" Discuss student ideas, including how using repeating forms is simpler and more efficient, using less energy.
- Pass out the "Annelid 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 Annelids" handout. Ask students to share details about the shared adaptations of annelids that they learned from the fact sheet, videos, or other sources:
  - Segmentation
  - A long shape with bilateral symmetry
  - A coelom (body cavity)
  - A complete circulatory system
  - A body wall made of circular and long muscles
  - Bristle-like structures, called setae
  - A continuous gut running from mouth to anus

  They might also share some of annelids' highly specialized methods of feeding, such as how tubeworms living near hydrothermal vents rely on bacteria eating hydrogen sulfide (and do not need to eat themselves) and how leeches can suck blood of living hosts.
- Close with a discussion of the characteristics of annelids that students found the most interesting. Fill in any important details, such as each segment of an annelid contains the essential unit of information needed to create the body plan. The basic unit is repeated with added features, such as the external and internal structures/features listed above. This helps the organism grow, survive, and reproduce. Their amazing adaptations and highly specialized feeding strategies have allowed annelids to live in an astounding range of habitats, from the deepest oceans to the digestive systems of a wide-range of animals.
- 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.



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Shape of Life

Annelid Trivia KEY

1. Which of the below are annelids? (Circle all that apply.)
   a. Amphibians
   b. Crustaceans
   c. Spaghetti worms
   d. Giant tubeworms
   e. Earthworms
   f. Leeches
2. Put an "X" or checkmark in front of all the habitats listed below where you might find annelids.
   X Ocean waters
   X Damp soils
   X Freshwater ecosystems
   X Hydrothermal vent communities
   X Tidal zones
   X Digestive systems of other animals
3. Annelids can be which of the following? (Check all that apply.)
   X Carnivores
   X Detritovores
   X Herbivores
   X Parasites
   X Omnivores
4. Mark all the things below that annelids eat.
   X Small invertebrates
   X Dead fish
   X Zooplankton
   X Microorganisms
   X Bacteria fed by hydrogen sulfide
   X Small particles of organic matter in seawater
5. All adult annelids have bilateral symmetry.
   X True
   ___ False
6. All annelids have a complete **circulatory system**.
   X True
   ___ False
7. All annelids have both circular and **longitudinal** (long) muscles.
   X True
   ___ False
8. Annelid fossils have been found on Mars.
   ___ True
   X False

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

Extend/Enrich

- Guide students through an activity about bilateral symmetry. (15 minutes or more)
    - A lesson targeted to grade 4 is explained here: arttango.com/fourth_grade_art_lessons/fourth_grade_Lesson_11.html
    - An example that integrates technology – "Using Minecraft as a Tool to Assess Students' Understanding of Symmetry": sarahvanloo.com/category/arts-education
    - Try to help students see the connections between art with repeating patterns and the **segmentation** and **bilateral symmetry** of annelids. Ask them to think about and discuss how drawing symmetrical designs can help us understand the benefits of a bilateral body plan. For example, well-reasoned scientific theories include:
        - Being symmetrical helps animals move forward (and sometimes also backward) in a straight line. This helps the animals move quickly and efficiently, which helps explain why most animals alive today have a bilateral body plan. It also helps in hunting, in part due to the binocular vision made possibly by having two aligned eyes, which helps with depth perception.
        - Symmetry is also a useful strategy that guides cell division and the development of organisms. It helps organisms grow from one cell to many cells in an organized way in which each new cell has a copy of the necessary genetic material.
        - Learn more: "The Reason Why Most Animals are Symmetrical Has to Do with Their Locomotion." CBC (2:56): cbc.ca/player/play/1282044483538
    - By creating bilaterally symmetrical designs, students begin to understand this property in an embodied way as they continuously refer back to one side of the design to create the other side to match. 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 annelids and other symmetrical organisms and analyzing their structures can support the creation of the art, by offering a set of colors, shapes, and patterns and even symbolic meaning that can inform creative choices around the design.
    - You might also share images of symmetry in fine art, such as those shown on this "Balance, symmetry, and emphasis" page of the Smarthistory site by Dr. Asa Simon Mittman: smarthistory.org/balance-symmetry-and-emphasis
- Students choose annelid species to research and present to the class. (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.
    - Interesting species you might suggest for individual students and / or group research include:
        - Bone-eating worms: montereybayaquarium.org/animals/animals-a-to-z/whale-worm

- Fat innkeeper worms: montereybayaquarium.org/animals/animals-a-to-z/fat-innkeeper-worm
- Leeches: shapeoflife.org/video/annelids-leeches
- Lumbricus, earthworms: shapeoflife.org/video/annelids-lumbricus-earthworm
- Red wrigglers *(Eisenia fetida)*: alabamawildlife.org/wonders-of-wildlife-red-wiggler
- Spaghetti worms: shapeoflife.org/video/annelids-terrebellid-spaghetti-worm
- Tube-dwelling worms: shapeoflife.org/video/annelids-diopatra-tube-dwelling-worm

- 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.

- Work with students to create worm bins, which turn food and paper waste into useful compost.

  More about the process and the ideal worms to use is explained at many sites online, such as:

  - "Worm Bins." Cornell Composting: compost.css.cornell.edu/worms/wormhome.html
  - "Wormy Facts and Interesting Tidbits (by Rhonda Sherman): composting.ces.ncsu.edu/vermicomposting-2/wormy-facts-and-interesting-tidbits

- Conduct a field study to observe live annelids. (Will vary)

  Take students on a field study to an area such a schoolyard, stream, seashore, garden, or aquarium where students can observe live annelids and their ecosystems firsthand.

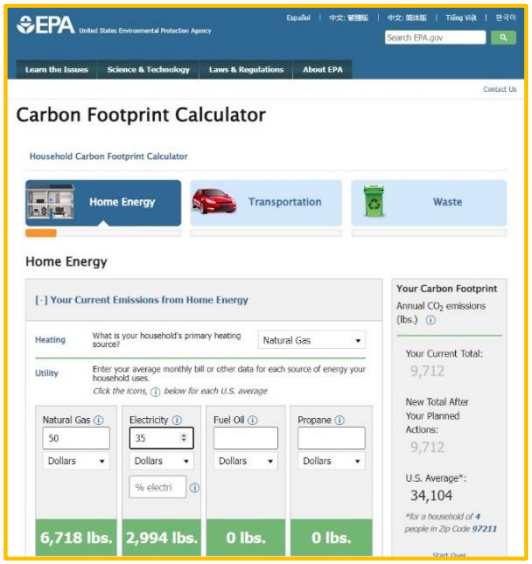
Students sort marine organisms during a BioBlitz with the Natural History Museum of Los Angeles County.
National Park Service: flickr.com/photos/santamonicamtns/26968299982

  - 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 scientific research, events, and / or career connections related to annelids. (1 – 20 min.)

  Find news highlighting scientific findings or questions about annelids. This will make the activities and discussions more relevant and personal to the students.

  - For instance, you can share exciting research by students / young researchers such as Eesha Rangani: scripps.ucsd.edu/news/scripps-student-spotlight-eesha-rangani
  - Or you could highlight exciting discoveries, such as those explained in the articles below. Students could choose an article that most interests them to read with a small group and summarize for the class.
    - "Ancient Sea-Worm Mystery Solved by Student After 50 Years in "Wastebasket": scitechdaily.com/ancient-sea-worm-mystery-solved-by-student-after-50-years-in-wastebasket
    - Damhnait McHugh: "Worm Woman" talks about jumping worms: shapeoflife.org/news/featured-scientist/2020/06/16/damhnait-mchugh-raab-family-chair-and-professor-biology-colgate
    - "Highly Invasive Jumping Worms Have Spread to 15 States": smithsonianmag.com/smart-news/highly-invasive-jumping-worms-have-spread-15-us-states-180977566
    - "Oldest relative of ragworms and earthworms discovered": phys.org/news/2020-06-oldest-relative-ragworms-earthworms.html
  - Impacts of the climate crisis on annelids could also stimulate thinking, discussion, and solutions-oriented action. You could start by asking students to read and reflect on an interesting article, such as: "A Hotter Planet Could Change One of Nature's Most Important and Unseen Creatures": inverse.com/science/60414-earthworms-biodiversity-climate
  - 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 set up with other activities related to annelids 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 student 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 annelid structural and behavioral adaptations with their art, including ways they are able to acquire food and escape predators.

Expand Knowledge + Skills

Related Lesson Plans / Resources

- "Artful Echinoderms." Shape of Life: shapeoflife.org/lesson-plan/artful-echinoderms
- 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
- "Earthworms are Easy: A Composting System for Kitchen Waste": ucanr.edu/sites/solanomg/files/245169.pdf
- "I Notice, I Wonder, It Reminds Me Of" student activity guide. BEETLES, Lawrence Hall of Science: beetlesproject.org/cms/wp-content/uploads/2015/12/I-Notice-I-Wonder-It-Reminds-Me-Of.pdf
- "Let It Rot" lesson plan. Smithsonian: gardens.si.edu/learn/educational-resources/garbage-to-gardens/let-it-rot
- "Making an Earthworm Observatory" lesson plan. Smithsonian: serc.si.edu/sites/default/files/making_an_earthworm_observatory_lesson_plan.pdf
- "Modeling Evolutionary Relationships with Trees" lesson plan. Shape of Life: shapeoflife.org/lesson-plan/sol/modeling-evolutionary-relationships-trees
- "Science in Action!" lesson plan. Shape of Life: shapeoflife.org/lesson-plan/sol/science-action

Annelids

- "The Next Segment: An Explosion of Life." Shape of Life: shapeoflife.org/sites/default/files/global/TheNextSegmentAnnelids.pdf
- "Worms: Phyla Platyhelmintes, Nematoda, and Annelida." Exploring Our Fluid Earth: Teaching Science as Inquiry (TSI). Univ. of Hawai'i: manoa.hawaii.edu/exploringourfluidearth/biological/invertebrates/worms-phyla-platyhelmintes-nematoda-and-annelida
- "Annelids." CK-12: flexbooks.ck12.org/cbook/ck-12-biology-flexbook-2.0/section/11.9/primary/lesson/annelids-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 greatly appreciate all you do and welcome your questions or comments.

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Shape of Life

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Artful Annelids

The art below by German biologist/artist Ernst Haeckel is from the influential book *Kunstform en der Natur*, 1904.

The complete original source is at biodiversitylibrary.org/page/33543710.

Think About It!

1. What characteristics are common to all annelids?

2. What art and/or engineering designs do annelids inspire you to create?

Repeating Forms in Architecture

The beautiful buildings below use repeating forms, not unlike segmentation in annelids.

The Marin Center, which was designed by Frank Lloyd Wright, perhaps the most famous American architect. "Nature, above all else, was Wright's most inspirational force." Quoted from "Frank Lloyd Wright and Nature." Guggeheim Museum: guggenheim.org/teaching-materials/the-architecture-of-the-solomon-r-guggenheim-museum/frank-lloyd-wright-and-nature Image: CC BY-SA 4.0: commons.wikimedia.org/wiki/File:Marin_Civic_Center_outside.jpeg

Petronas Towers (center) and other skyscrapers in Kuala Lumpur, Malaysia

Think About It!

1. How do these buildings compare to the annelid body plan?

2. How might repeating forms create benefits for both annelids and building design / construction?

Name: _____ Date: _____

Shape of Life
The Story of the Animal Kingdom

Annelid Trivia

1. Which of the animals below are classified as annelids? (Circle all that apply.)
   a. Amphibians
   b. Crustaceans
   c. Spaghetti worms
   d. Giant tubeworms
   e. Earthworms
   f. Leeches

2. Put an "X" or checkmark in front of all the habitats listed below where you might find annelids.
   ___ Ocean waters
   ___ Damp soils
   ___ Freshwater ecosystems
   ___ Hydrothermal vent communities
   ___ Tidal zones
   ___ Digestive systems of other animals

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

4. Mark all the things below that annelids eat.
   ___ Small invertebrates
   ___ Dead fish
   ___ Zooplankton
   ___ Microorganisms
   ___ Bacteria fed by hydrogen sulfide
   ___ Small particles of organic matter in seawater

5. All adult annelids have **bilateral symmetry**.
   ___ True
   ___ False

6. All annelids have a complete **circulatory system**.
   ___ True
   ___ False

7. All annelids have **segmentation** and a long shape.
   ___ True
   ___ False

8. All annelids have both circular and **longitudinal** (long) muscles.
   ___ True
   ___ False

9. Annelid fossils have been found on Mars.
   ___ True
   ___ False

Name: _____ Date: _____

Shape of Life
The Story of the Animal Kingdom

Annelid Trivia KEY

1. Which of the below are annelids? (Circle all that apply.)
   - a. Amphibians
   - b. Crustaceans
   - c. Spaghetti worms
   - d. Giant tubeworms
   - e. Earthworms
   - f. Leeches

2. Put an "X" or checkmark in front of all the habitats listed below where you might find annelids.
   - X Ocean waters
   - X Damp soils
   - X Freshwater ecosystems
   - X Hydrothermal vent communities
   - X Tidal zones
   - X Digestive systems of other animals

3. Annelids can be which of the following? (Check all that apply.)
   - X Carnivores
   - X Detritovores
   - X Herbivores
   - X Parasites
   - X Omnivores

4. Mark all the things below that annelids eat.
   - X Small invertebrates
   - X Dead fish
   - X Zooplankton
   - X Microorganisms
   - X Bacteria fed by hydrogen sulfide
   - X Small particles of organic matter in seawater

5. All adult annelids have bilateral symmetry.
   - X True
   - ___ False

6. All annelids have a complete **circulatory system**.
   - X True
   - ___ False

7. All annelids have both circular and **longitudinal** (long) muscles.
   - X True
   - ___ False

8. Annelid fossils have been found on Mars.
   - ___ True
   - X False

Name(s): _____ Date: _____

Shape of Life
The Story of the Animal Kingdom

I Notice, I Wonder, It Reminds Me Of

This organizer can help you record your observations, thoughts, and ideas.

Things I Notice 	What I Wonder About ? ? ?	Things it Reminds Me Of 

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: