Shape of Life
The Story of the Animal Kingdom

Cidarian Adaptations

Exploring the Roots of Animal Adaptations

Overview

Students explore the origins of muscles, nerves, and other animal adaptations through a study of the fascinating phylum Cnidaria (nahy-dare-ee-uh). They will have the opportunity to observe the predatory organisms, including sea anemones and jellies and their amazing adaptations that they use to catch prey, defend themselves, etc. in one or more Shape of Life video segments. Students will record notes about physical and behavioral adaptations, then create a diagram of their favorite cnidarian species, labeling its structures and adding annotations to describe their functions. Possible extensions are listed at the end of the lesson, including a comparison activity and field studies.

Objectives

- Students will describe cnidarian adaptations orally and in writing.
- Students will create labeled diagrams of a cnidarian species of their choice.
- If the comparison extension is completed, students will compare adaptations of a cnidarian species to those of another animal.

Subjects

Science, Environmental Education, Writing, and Art

Grades 6–12

Time

45–90 minutes

Vocabulary

Adaptations, cnidaria, cnidarian, corals, gastrovascular cavity, hydra, jellies, medusa, nematocyst, polyp, predator, sea anemone, zooplankton

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.
	Disciplinary Core Ideas	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
	Crosscutting Concepts	• Cause and effect • Structure and function • Systems and system models
	Science & Engineering Practices	• Developing and Using Models • 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

Animals of the phylum Cnidaria come in various body shapes and have different ways of living. For example:

- **Corals** are cnidarians that live in **colonies**. About 800 species are known that create hard reefs, which are critically important areas for **biodiversity** around the world. They create their rock-like skeletons by secreting calcium carbonate. Many other species of "soft corals," such as sea fans and sea feathers, live in colonies with a plant-like appearance. Coral colonies generally consist of hundreds of thousands of individual organisms.
- The body plan of **jellies** is like an anemone that has been turned upside down. This diverse group of cnidarians thrives at all depths of the ocean.
- **Hydra** (plural **hydrae**) are small, freshwater cnidarians that can extend their tentacles many times the lengths of their bodies. They are also unique and amazing because they can regenerate themselves from continually renewed stem cells, making them essentially immortal (Watry 2018).

Life Cycle and Body Forms of Cnidarians

Many cnidarians alternate between the two different body forms during their lives. One is the free-swimming form, called a **medusa**, and the other is a stationary form, called a **polyp**. For example, each individual coral animal is a polyp.

Moon jelly in "Cnidarians: Moon Jelly Life Cycle" and "Cnidarians: Life on the Move" videos

Both body forms follow the same basic cnidarian body plan. The polyp is sessile (fixed in place), living on a substrate with the tentacles extending up, and the medusa is free-swimming, with the tentacles extending down. Many polyps never turn into medusae (e.g. the hydra), but most medusae or jellies have a polyp stage. The polyp form asexually buds off tiny juvenile medusae, called **ephyra**, which grow into adult jellies that reproduce sexually (see video "Cnidarians: Moon Jelly Life Cycle").

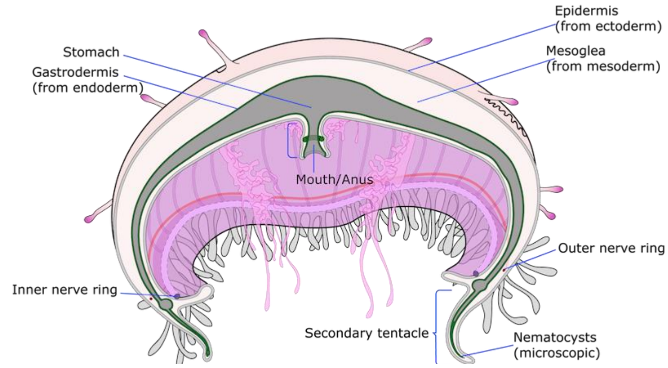
Although they are relatively simple organisms, all cnidarians have certain important structures in common:

- ### Muscles + Nerves

  Significant scientific evidence indicates that **cnidarians** were the first animals to have **muscles** and **nerves** to produce behavior. Their simple **nervous system** is made up of a **nerve net** which transmits messages between the muscle cells, causing them to contract. One genus of anemones, *Stomphia,* can actually swim away from predators by contracting its entire body.

- ### Mouth + Stomach

  The evidence indicates that cnidarians were also the first animals to have a mouth and stomach to digest food. In the polyp form, **tentacles** ring the mouth at the top of the bag-like stomach, called a **gastrovascular cavity**. In the medusa form of jellies, the umbrella-like top covers the tentacles and mouth, which leads up to the gastrovascular cavity. By filling the cavity with water and tightly closing their mouths, cnidarians give their bodies structure in the absence of a true skeleton or shell by "putting the water under pressure as in a balloon filled with water" ("Phylum Cnidaria," Exploring Our Fluid Earth). This is referred to as a **hydrostatic skeleton**.



Jelly cross section diagram by Mariana Ruiz Villarreal, Wikimedia Commons

- Nematocysts

  All cnidarians are **predators** that have **cnidocytes**, specialized cells on the end of their tentacles that each contain a **nematocyst** (also known as **cnidoblast**)—a harpoon-like structure used for protection and capturing prey, often barbed and delivering toxins, with varying amounts of it depending on the species. Touch (or occasionally chemicals) will trigger the high-speed release of the nematocysts. In the Shape of Life video "Cnidarians: Life on the Move," students learn about the structure and function of **nematocysts** through the dramatic scenes of an anemone catching a goby fish and of two anemones using them as weapons in their fight for space.

Deep Sea Cnidarians

- Cnidarians are among the most abundant inhabitants of the deep sea, where they play crucial roles in Earth's largest ecosystem.
- While their nematocysts unite them into a single phylum, they have evolved a remarkable diversity of shapes, sizes, and strategies to enable their predatory lifestyle.
- All the deep-sea cnidarians combined comprise one of the largest living biomasses on the planet.

Materials + Preparation

Anemones in "Cnidarians: Life on the Move"

- Shape of Life video "Cnidarians: Life on the Move" (14:44) available online: shapeoflife.org/video/cnidarians-life-move
- Decide if you will show the video to the whole class and/or have partners view the video while taking notes about cnidarian adaptations and/or sketching them.
- Other short videos that will be used in the Explain portion of the lesson are available at shapeoflife.org/cnidarian, such as "Cnidarians: Anemone Catches Goby" (2:22): shapeoflife.org/video/cnidarians-anemone-catches-goby
- Computer with Internet connection and data projector if you plan to show all or part of the video to the whole class
- Science notebook and pencil or pen for each student
- Whiteboard or chart paper and markers
- *Optional:* Colored pencils and/or markers for students to share

Teaching Suggestions in the 5E Model

Engage

1. Options to "hook" students and introduce the lesson. (2–3 min.)

- Ask students to think about the incredible diversity of life that lives in the ocean and ask, "What sea creatures do they think might have been the very first animals to be able to move in the history of life on Earth?"
- Give the students a minute to brainstorm ideas with a partner, then ask the groups to share their ideas with the whole class and discuss.
- Tell the students that today they will be learning about the fascinating organisms that scientists believe were the first to evolve muscles and nerves, giving them the ability to move—**cidarians**.
- Instead of, or in addition to, the brainstorming activity, ask the students to complete the "Cnidaria Trivia" activity at the end of the lesson to see what they already know about the phylum and prime them for the lesson. You could also ask them to try to answer trivia questions orally (with or without a partner), such as:
    - What are cnidarians? (Animals in the phylum Cnidaria, such as sea anemones, jellies, and corals)
    - Are Cnidarians carnivores, herbivores, or omnivores? What kinds of things do they eat? (Carnivores that capture prey such as fish and zooplankton (tiny sea animals))
    - True or false? All cnidarians have nerves and muscles. (True: Scientists believe they are the organisms that first evolved these amazing adaptations that all animals inherited.)
    - True or false? All cnidarians have a mouth and a stomach. (True)

Explore

2. Students watch "Cnidarians: Life on the Move" and consider cnidarian adaptations. (20 min.)

- Depending on how many computers and/or other devices your students have access to, consider asking them to watch it with a partner while thinking about the **adaptations** that help the cnidarians survive. They should record notes about the physical adaptations (body structures) and behavioral adaptations (things the organisms do) that help them to survive, including simple sketches of the organisms and their important structures. They also might add arrows or other symbols to indicate movements and other processes. Consider giving them a choice between recording notes in science notebooks and a digital format.
- Encourage students to turn on closed captioning using the CC button so they can read along with the video. Students can also use headphones, if available, to better hear the narration and minimize distractions to other groups.
- Circulate through students, answering questions and providing feedback, as necessary.

Explain

3. Discuss important concepts and terms with students. (4–10 min.)

- Gather students together and briefly discuss their ideas about cnidarian adaptations.
- Discuss important adaptations explained in the Teacher Background section, writing them on the board and asking students to take notes on them in science notebooks. Use the short videos on the Shape of Life website as visual aids, such as "Cnidarian Animation: Anemone Body Plan" (3:04):

"Cnidarian Animation: Anemone Body Plan"

shapeoflife.org/video/cnidarian-animation-anemone-body-plan

- Discuss the fact that many cnidarians alternate between the two different body forms during their lives. One is the free-swimming form, called a **medusa**, and the other is a stationary form, called a **polyp**. For example, each individual coral animal is a polyp.
- Both body forms follow the same basic cnidarian body plan. The polyp is sessile (fixed in place), living on a substrate with the tentacles extending up, and the medusa is free-swimming, with the tentacles extending down. Many polyps never turn into medusae (e.g. the Hydra). But most medusae or jellies have a polyp stage, which asexually buds off tiny juvenile medusae, called **ephyra**, which grow into adult jellies that reproduce sexually (see video "Cnidarians: Moon Jelly Life Cycle").

Moon jelly medusa in "Cnidarians: Moon Jelly Life Cycle"

- All cnidarians have **cnidocytes**–special cells on their tentacles that contain tiny harpoons called **nematocysts** used to capture prey and protect themselves. Explain that this is a characteristic that unites all of the organisms in the Cnidaria phylum. Use "Cnidarians: Anemone Catches Goby" (2:22) as a visual aide to show predation using these unique structures: shapeoflife.org/video/cnidarians-anemone-catches-goby

Nematocyst animation in "Cnidarians: Anemone Catches Goby"

- Show the short clip "Cnidarians: Anemones Fight" (2:49) with the audio muted and ask student volunteers to explain what is happening using the correct terms: shapeoflife.org/video/cnidarians-anemones-fight. You can then show "Nematocyst Animation: Fighting Tentacles" (1:48) to review how nematocysts work: shapeoflife.org/video/nematocyst-animation-fighting-tentacles
- Explain that the name Cnidaria comes from the Greek word "cnidos," which means stinging nettle.

"Cnidarians: Anemones Fight"

- Show a clip from "Cnidarians: Deep Sea Research" and talk about how cnidarians are among the most abundant inhabitants of the deep sea, where they play crucial roles in Earth's largest ecosystem: shapeoflife.org/video/cnidarians-deep-sea-research. Discuss how their nematocysts unite them into a single phylum, but cnidarians have evolved a remarkable diversity of shapes, sizes, and strategies to enable their predatory lifestyle. Explain that the bodies of these animals comprise one of the largest living biomasses on the planet.

"Cnidarians: Deep Sea Research"

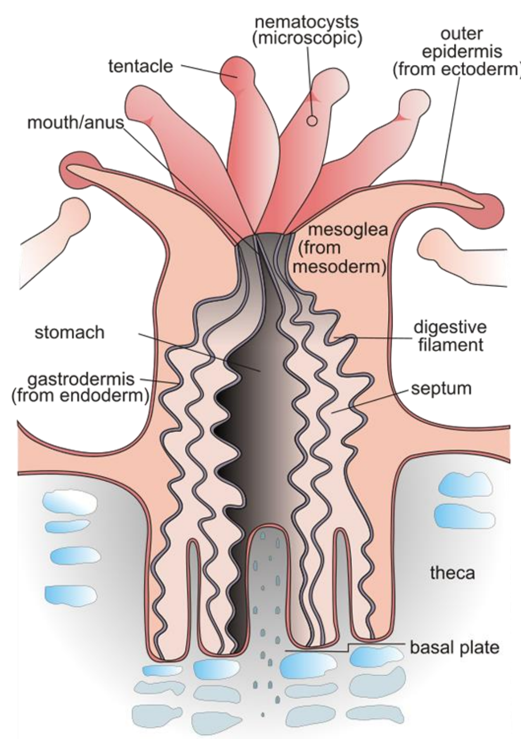
4. Discuss how understanding cnidarian structures and their functions helps us understand the evolution of animal adaptations. (2–10 min.)

- Ask students to reflect on how cnidarian adaptations, such as muscles and nerves, help to explain the evolution of animals. (For example, the cnidarians' simple **nerve net** and muscles can create fairly complex behaviors. Escaping a predator is certainly an adaptive behavior.) This can first be done as a think-pair-share activity before discussing it as a class.
- Watch "Cnidarians: Anemone Swims Away from Sea Star" (2:01) to show a simple nervous system creating a complex behavior: shapeoflife.org/video/cnidarians-anemone-swims-away-sea-star


"Cnidarians: Anemone Swims Away from Sea Star"

- Relate the important concept of cause and effect to your discussion. For example, talk about how their nerve net transmits messages between the muscle cells, causing them to contract. In the case of jellies, this process results in their distinctive, rhythmic movement. Combined with ocean currents and wind, jellies are able to traverse the global ocean.
- *Optional:* You might also discuss how natural selection of species through competitive pressures can result in the long-term effects of evolutionary changes over time. What might have caused the further evolution of cnidarian structures into those found in other modern animals, including humans?
- Discuss how **corals** are cnidarians that live in **colonies**. About 800 species are known that create hard reefs, which are such important areas for **biodiversity** around the world. They create their rock-like skeletons by secreting calcium carbonate. Many other species of "soft corals," such as sea fans and sea feathers, live in colonies with a plant-like appearance). Coral colonies generally consist of hundreds of thousands of individual organisms.

"Anatomy of a Coral Polyp" from NOAA, adapted by the Univ. of Hawaii



5. Students create a detailed model of a cnidarian. (20 min.)

- Ask students to make a detailed scientific sketch of their favorite cnidarian species, labeling the individual structures and their functions. Consider sharing an exemplar that you or a student created, or share a model online, such as:
  - "The Anatomy of a Coral Polyp" diagram shown to the right from the Univ. of Hawaii, adapted from NOAA: manoa.hawaii.edu/exploringourfluidearth/media_colorbox/3366/media_original/en
  - Diagram of a jelly by Byron Inouye: manoa.hawaii.edu/exploringourfluidearth/media_colorbox/3171/media_original/en

- Students should be encouraged to add labels and annotations (more detailed explanations of the features of the diagrams). They can also color their diagrams and explain them in writing, including the adaptations that help the organisms to survive.
- Diagrams can be completed with the support of reference materials such as books and those on the Internet.

Extend / Enrich

6. Students compare a cnidarian species to another organism. (10–20 min.)

    - Ask the students to compare a cnidarian with another organism—either a modern one or an ancient ancestor. For example, a Venn diagram or another type of graphic organizer could be used. Then students could explain their graphic organizers in writing.
    - Oral presentations can be given to the class which explain the analytical comparisons.

7. Conduct a field study at a tidepool or aquarium so students can observe and compare living cnidarians. (Will vary)

    - Take students on a field trip to a tidepool, aquarium, or other area where students can observe cnidarians and their ecosystems first hand.
    - Be sure students are prepared with appropriate clothing, safety rules, ways to avoid damaging the ecosystem, etc.

8. Observe cnidarians under magnification. (1 – 20 min.)

    - If you have access to live cnidarians, either in the wild or at an aquarium or in the classroom, students can view them and/or their body structures under magnification via a microscope, hand lens, and/or macro lens to better see their unique adaptations.
    - You can also use a microscope or macro lens connected to a computer and/or data projector to show them to the whole class.

9. Dissect cnidarians. (10 – 20 min.)

    You can prepare to lead students in a dissection—or they can lead themselves—with the support of videos and/or other resources listed below and at the end of the lesson, such as:

    - "Jellyfish and Anemone Anatomy (Cnidaria)" (9:51): http://dissection101.blogspot.com/2013/02/phylum-cnidaria-jellyfish-and-sea.html
    - "How to Dissect a Sea Anemone" listed under "How-To Videos on methods in Sea Anemone taxonomy and systematics." Bocas ARTS: bocasarts.weebly.com/sea-anemone-tools.html
    - "Phylum Cnidaria." Lumen Learning: courses.lumenlearning.com/boundless-biology/chapter/phylum-cnidaria

10. Discuss current events related to one or more cnidarian species. (1 – 20 min.)

    - Find some local news highlighting issues related to cnidarians, such as jellies. This will make the activities and discussions more relevant and personal to the students.

- Other important news related to cnidarians, such as the impacts of climate change on coral reefs, would also stimulate thinking and discussion.
- Discuss how jellies are taking over the ocean and clogging fishing nets. One excellent article that would provide a springboard for discussion is "The Global Jellyfish Crisis in Perspective" by Juliet Lamb on JSTOR Daily: daily.jstor.org/global-jellyfish-crisis-perspective

11. Students can conduct in-depth research projects about a cnidarian species, its life cycle, and/or one or more of its adaptations. (60 min. or more)

    The video "Cnidarians: Moon Jelly Life Cycle" (3:15) succinctly explains the life cycle of these fascinating creatures.

"Cnidarians: Moon Jelly Life Cycle"

12. Students can write fictional stories or poems that involve cnidarians. (15 min. or more)

    Stories can include one or more cnidarian species. For example, it be an imaginative piece about a day in the life of a cnidarian, or could be set in a coral reef attempting to cope with a warming ocean and ocean acidification.

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

    Classroom centers can be setup with other activities related to cnidarians 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

14. Students can present their diagrams, comparisons, and/or other projects to the class.

    - Provide a rubric such as the one at the end of the lesson so students know how they will be assessed.
    - 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).
    - 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.

15. Review completed student diagrams and science notebooks.

    - Review student diagrams, labels, and annotations.
    - Check that they have explained cnidarian structural and behavioral adaptations, including ways they are able to catch food, reproduce, and escape predators.

16. Closing discussion / reflection (1 – 5 min.)

    - Students can be asked to reflect on what they learned in the lesson, including about cnidarian adaptations, orally and/or in writing. They can also be asked to reflect on what you, as the teacher, might do to improve the lesson next time.
    - Ask how cnidarian adaptations of muscles, nerves, and other structures help to explain the evolution of animals.

Expand Knowledge + Skills

Cidaria Background

- "Phylum Cnidaria." Exploring Our Fluid Earth: Teaching Science as Inquiry (TSI). Univ. of Hawai'i: manoa.hawaii.edu/exploringourfluidearth/biological/invertebrates/phylum-cnidaria
  - Coral diagram and description: manoa.hawaii.edu/exploringourfluidearth/media_colorbox/3366/media_original/en
  - Jelly diagram: manoa.hawaii.edu/exploringourfluidearth/media_colorbox/3171/media_original/en
- Fautin, D.G. & Romano, S.L. "Cnidaria." Tree of Life web project: tolweb.org/Cnidaria
- "Introduction to Cnidaria." Univ. of California Museum of Paleontology: ucmp.berkeley.edu/cnidaria/cnidaria.html
- "What are corals?" International Coral Reef Institute: icriforum.org/about-coral-reefs/what-are-corals
- "Scientists Say: Nematocyst." Science News for Students: sciencenewsforstudents.org/blog/scientists-say/scientists-say-nematocyst
- "Cnidaria." Wikipedia (also references many other excellent sources): en.wikipedia.org/wiki/Cnidaria
- Watry, G. (2018). "Hydra and the Quest to Understand Immortality." UC Davis College of Biological Sciences: biology.ucdavis.edu/news/hydra-and-quest-understand-immortality

Related Videos

- "Ian Lawn, Neurobiologist: Anemone Nervous System." Shape of Life: shapeoflife.org/video/ian-lawn-neurobiologist-anemone-nervous-system
- "Jellyfish and Anemone Anatomy (Cnidaria)." youtube.com/watch?v=eC5-y_oTI2Q
- "How to dissect a sea anemone" (4:21). Smithsonian Tropical Research Institute: youtube.com/watch?v=Eoez4x_5pDQ

Related Lesson Plans / Activities

- "Activity: Nematocysts." Exploring Our Fluid Earth: Teaching Science as Inquiry (TSI). University of Hawai'i: manoa.hawaii.edu/exploringourfluidearth/biological/invertebrates/phylum-cnidaria/activity-nematocysts
- "Activity: Corals." Exploring Our Fluid Earth: Teaching Science as Inquiry (TSI). University of Hawai'i: manoa.hawaii.edu/exploringourfluidearth/biological/invertebrates/phylum-cnidaria/activity-corals
- "Invertebrate Critter Cards." Shape of Life: shapeoflife.org/sites/default/files/lesson-plans/Invertebrate%20Critter%20Cards%20Activity__0.pdf
- "World's Most Awesome Invertebrate." Shape of Life: shapeoflife.org/sites/default/files/SoL-Lesson-Awesome-Invertebrate_0.pdf

Standards

- 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
- Examples of what NGSS looks like for California students can be found in the 2016 Science Framework for California Public Schools: cde.ca.gov/ci/sc/cf/documents/scifwchapter4.pdf
- Common Core State Standards and links to the complete documents: corestandards.org

Cnidaria Trivia

1. What are cnidarians? (Circle one)
   a. Amphibians
   b. Crustaceans
   c. Fish
   d. Insect larvae (young insects)
   e. Molluscs (mollusks)
   f. None of the above
2. Put an "X" or checkmark in front of all the animals below that are classified as cnidarians.
   ____ Clams
   ____ Corals
   ____ Jellyfish
   ____ Sea anemones
   ____ Sea slugs
   ____ Starfish
3. Cnidarians are:
   ____ Carnivores
   ____ Herbivores
   ____ Omnivores
4. Mark all the things below that cnidarians eat.
   ____ Algae
   ____ Fish
   ____ Zooplankton
   ____ Sea turtles
   ____ Sea grass
   ____ Sea grass
5. All cnidarians have nerves and muscles. Scientists believe they are the organisms that evolved these amazing adaptations that all animals inherited.
   ____ True
   ____ False
6. All cnidarians have a mouth and a stomach.
   ____ True
   ____ False
7. All cnidarians have **cnidocytes**–special cells at the end of their tentacles. These contain **nematocysts** that are like tiny harpoons with toxins that are used to capture prey and protect themselves.
   ____ True
   ____ False

Name(s): ____ Date: _________________

Presentation Rubric

Title: ____

Presentation Component	Maximum Points Possible	Self-Score (fill out before presentation)	Teacher Score
Part 1: Content			
Subject and purpose of presentation clearly introduced	10		
Key concepts identified and clearly explained in well-organized way	10		
Ideas supported by examples, data, graphs, etc.; All information accurate and obtained from reliable sources	10		
Conclusion summarizes key points in persuasive way; 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	10		
Speaker demonstrates enthusiasm for topic throughout presentation; audience is persuaded by speaker	10		
Part 3: Visuals			
Visuals help to clearly explain concepts	10		
Part 4: Writing Conventions			
Grammatical and spelling conventions followed	10		
TOTALS:	**100**		

Comments: