Students are challenged to design and build a museum display for a new exhibit at The Tech Museum of Innovation in San Jose, California. The exhibit will explore anatomy, physiology, and development. Students will: research a selected body system; develop exhibit text, diagrams, charts, and graphs; and design and build an analogous model.

Human Body Exhibit

Grades 6-12
Estimated time: 18-20 sessions (50 minutes)

Student Outcomes:
1. Students will be able to design, build, and interpret a working, analogous model of some aspect of an assigned body system.
2. Students will be able to explain design considerations based on scientific concepts and research.
3. Students will be able to utilize the three step design process to meet a design challenge.

Next Generation Science Standards
Grade 6-8: Engineering Design MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4;
Grade 9-12: Engineering Design HS-ETS1.1, HS-ETS1.2, HS-ETS1.3; Life Science HS-LS1-2, HS-LS1-4, HS-LS1-7, HS-LS2-5;

Common Core Language Arts-Speaking and Listening
Grade 7: SL.7.1b-d
Grade 8: SL.8.1b-d
Grade 9-10: SL.9-10.1b-d, SL.9-10.2, SL.9-10.3, SL.9-10.4
Grade 11-12: SL.11-12.1.b-d, SL.11-12.2, SL.11-12.4

Vocabulary:
Familiarity with these terms and concepts will enhance students' experience in the activity. Additional vocabulary words should be made available to students once assigned their specific scientific principle or process.

- **Analogy**: A comparison between two things, typically on the basis of their structure and for the purpose of explanation or clarification.
- **Body System**: One of the many systems that comprises the human body. This includes in integumentary system, skeletal system, nervous system, cardiovascular system, endocrine system, muscular system, lymphatic system, respiratory system, urinary system, excretory system, reproductive system, digestive system, and immune system.
- **Design**: Realization of a concept or idea into a configuration, drawing, model, pattern, plan, or specification which helps achieve the item's designated objective(s).
- **Interpretation**: Refers to all the way in which information is communicated to visitors at an educational site, such as a museum or science center. It is designed to reveal meanings and relationships through the involvement of objects, artifacts, landscapes and sites.
- **Iteration**: The act of repeating a process with the aim of approaching a desired goal, target, or result.

1 Adapted from Sarah Perry’s “Museum Exhibit Design Challenge for Human Body Systems.”
Human Body Exhibit
Design Challenge Learning

- **Label:** a caption describing an object exhibited in a museum, or one introducing a room, area, or the whole museum.
- **Model:** A three-dimensional representation of something, typically on a smaller scale than the original – something used as an example to follow or imitate.

### Basic Project Timeline

**Session 1**
- Introduce the challenge and general project outline.

**Session 2**
- Choose teams and assign topics.
- Have teams establish team expectations by which to govern their project.
- Teams begin researching topics individually.

**Session 3-4**
- Provide the framework for Brainstorming and Team Planning.
- Teams continue to research their topics.

**Session 5**
- Introduce principles of good exhibit design and creating labels.
- Teams engage in a mini design challenge of creating a label for an everyday object.
- Teams submit their initial design concept for approval.

**Session 6-10**
- Set expectations for the building period and go over safety instructions for tool use.
- Teams build their analogous model and exhibit display.

**Session 11**
- Teams engage in a design review and rehash their team plan based on the information gathered.

**Session 12-15**
- Provide background on museum interpretation.
- Teams continue to refine their exhibits and analogous models.
- By the end of session 15 all exhibits and guides should be complete.

**Session 16-17**
- Exhibit walk – teams demonstrate and engage others in their exhibits.

**Session 18**
- Closing discussion on the project and evaluation of teams.
Resources:

Design

- Stanford D.School: A Stanford University program that is a hub for innovators of all backgrounds to come together to solve problems. Their website provides a Virtual Crash Course in their Design Thinking methodology, including a video, facilitation guide, materials list, and supporting documents. They emphasize that “NO PREVIOUS DESIGN EXPERIENCE IS REQUIRED.”
- Dieter Rams and Good Design: A website about the company Vitsoe, it provides background on the influential industrial designer Dieter Rams (b.1932) and his philosophy on “Good Design”.
  [https://www.vitsoe.com/us/about/dieter-rams](https://www.vitsoe.com/us/about/dieter-rams)
- PRINT SOURCE: *The Non-Designer's Design Book* by Robin Williams: A quick, non-intimidating, and excellent resource on the design principles that govern good designs. The book is humor-infused, jargon-free, and includes design exercises, quizzes, and illustrations.

Analogies and Education

- “The Use of Analogy in Physics Learning and Instruction”: A paper prepared by Noah Podolefsky at the University of Colorado. It provides research on the theoretical framework describing analogy as well as the strategies for using analogies.
- Teaching and Learning with Analogies: An excerpt from pages 11-24 of P.J. Aubusson et al. (eds.):’s book *Metaphor and Analogy in Science Education* printed in 2006 by Springer in the Netherlands. The excerpt provides an understanding of the benefits and common pitfalls of teaching science through analogies.

Museum Exhibits and Interpretation

- A guide that provides suggestions for exhibit design. The guide was developed for National History Day Exhibits, but contains information on good exhibition design that reaches across disciplines. There is also an example of an exhibit design handout where students can plan their exhibit layout.
- An exhibit design and development workbook designed for the Texas Historical Commission. It is a comprehensive source on all aspects of designing a museum exhibit.
Design Challenge Process:

The Design Challenge Process is designed so students reinforce their science, mathematics, social studies, and language arts content knowledge, through an open-ended process that results in an original, team-driven solution. Students are expected to take responsibility for assessing their own progress and incorporate peer feedback as they conceptualize and redesign their projects.

The process consists of three interconnected steps:

**Conceptualize**
- Identify problem, materials, and constraints
- Brainstorm ideas and possible solutions

**Construct and Test**
- Select a solution
- Design and construct
- Prototype
- Redesign or modify
- Retest

**Acquire Knowledge**
- Research
- Share solutions
- Reflect and discuss

Through the try, fail, learn approach, students develop the skills and habits of mind of Silicon Valley innovators: creativity, problem solving, design, collaboration, leadership, risk-taking, perseverance, and learning from failure.

Materials:

Materials can be limiting or inspirational to students! Have a wide variety of materials to promote a diversity of solutions. "Recycled items" are really useful: old mouse pads, wood scraps, boxes, cardboard tubes, strawberry baskets, etc.

**Class Supplies to Share:**
- Art and Construction Supplies (No pre-built models)
- Computers with Internet Access
- Science Texts
- Research Materials
- Grumbacher Color Computer
- Hot Glue
- White Glue
- Wood Glue
- Tape (masking, scotch, painters, etc.)
- Screws
- Nails
- Nuts and Bolts
- Craft Sticks
- Doweling
- Wood Pieces (variety of sizes)
- General Office Supplies

**Suggested Art and Construction Supplies:**

For San Francisco Bay Area teachers, plan a visit to RAFT (Resource Area for Teaching) where you can pick-up bulk art, construction, and recycled materials. [www.raft.net](http://www.raft.net)
Lesson Plan:

Session 1: Introduce the Challenge (50 minutes)

1. **Scenario:** The Tech Museum of Innovation in San Jose, California is building a new exhibit and needs ideas for new, interactive displays. The exhibit is an exploration of anatomy, physiology, and development. In order to make the exhibit accessible to individuals with little-to-no science knowledge, they would like the displays to include interactive and hands-on analogous models.

2. **Challenge:** Design and create a museum exhibit/display that includes labels, an analogous device/model, and an exhibit interpretation guide based on an assigned human body system.

3. **Constraints:**
   - Your device must have at least one (1) moveable part and be able to withstand repeated but gentle use by other students.
   - You must make a drawing of your device and have it approved by the instructor before you start to build.
   - No pre-built parts or devices may be utilized.
   - You must include a display board or partitioning device to display information and keep your display separate from others.
   - Display must fit in a 2.5’ x 2’ space.
   - All pictures and information must be appropriately cited.
   - Everyone on the team must contribute to the exhibit/display.
   - All labels must be original work. **No plagiarism.**

4. **Building Information:** Design teams will be responsible for delivering their initial exhibit concept on session 5, a concept review on session 11, and their final product on session 16 for the opening of the exhibit. Teams will have a total of fifteen 50 minute sessions to research, design, build, test, and iterate their exhibit designs. During this time teams will be responsible for governing their own projects but may go to the instructor for input or mediation assistance. See the Timeline in “Additional Materials” for a breakdown of the project.

5. **Demonstration Information:** Design teams will be expected to serve as interpreters for their exhibit on opening day. They will be expected to not only demonstrate their exhibit, but also engage visitors (fellow classmates) in meaningful conversations about their exhibit. This conversation should not be one-sided, and exhibit interpreters should be asking the visitors open-ended questions to help meet specific learning outcomes designated by the instructor.

6. **Analogous Models:** Define an analogous model as making a comparison of two things that are topically unrelated, but whose structures are similar. Utilizing an already understood item or system to describe something unknown can help people understand new ideas and concepts. Present examples of analogies such as:
   - “Life is like a box of chocolate”: [https://www.youtube.com/watch?v=CJh59vZ8ccc](https://www.youtube.com/watch?v=CJh59vZ8ccc)
   - “Ogres are like onions”: [https://www.youtube.com/watch?v=bMceXVe8zIs](https://www.youtube.com/watch?v=bMceXVe8zIs)
   - Analogy of the Hunger Games to a Cell: [https://www.youtube.com/watch?v=Xo9L2FB7aDo](https://www.youtube.com/watch?v=Xo9L2FB7aDo)

7. **Field General Questions:** The instructor should leave time at the end of the discussion for questions. The instructor may encourage students to write questions on a 3x5 card and hand the cards in for the instructor to run through at the end of the session. These questions and answers can then be posted for all teams to reference as the project progresses.

Session 2: Teams, Topics, and Planning (50 minutes)

1. **Choose Teams and Assign Topics:** The instructor can pre-assign teams and topics, allow students to choose their own teams and topics, or use any other manner to ensure that teams are even and topics are not repeated. Following are some interactive ways to assign teams and topics:
• **Playing Cards:** Assign teams by shuffling a deck of playing cards and passing the cards out. Pre-stack the deck for only the number of students you have. Students with the same face become team mates.

• **Steal the Bacon:** Have teams face off for their preferred topics. Use a basketball court and place the “bacon” (any non-breakable object) in the center. Teams line up on the short edges. A content-based question is asked. One member from each team runs to the center to be the first to “steal the bacon.” The first person to steal the bacon gets three seconds to answer the question; if they answer correctly they get to choose their topic.

• **Image Puzzles:** Take an image of each of the systems and cut it into the number of people per team. Pass out the pieces randomly and have students find their partners and discover their topic by putting the pieces of the image together.

2. **Establish Team Expectations:** Have teams meet for no more than 20 minutes to prepare a set of expectations for their team as they proceed through the project. The instructor should give a brief – no more than 5 minutes – presentation on team management to help the students get started. See “Additional Materials” for a suggested team contract.

3. **Introductory Research:** Once teams are assigned, they should use the remainder of their time to individually begin the research phase of their project. They should have access to research materials including class texts, scholarly online resources, and a variety of other informational media (podcasts, videos, books, journals, images, etc.). Encourage students to answer questions in their text, record interesting facts, write down additional questions they had, and take note of any connections they made as they read.

**Session 3-4: (50 minutes each)**

1. **Brainstorming:** Review brainstorming guidelines with students. Instructor should emphasize that brainstorming is a period where ideas are shared – there should be no discussion until after all ideas have been presented. See “Additional Materials” for a hand out on brainstorming.
   - Give teams 10-15 minutes to brainstorm all their ideas for their project. Encourage them to stand up, draw pictures, use hand movements, write, talk, and post all of their ideas. You can further challenge your students by requiring each person or each team to develop a specific number of ideas.
   - Once brainstorming is complete, teams should then go through and discuss their ideas and narrow their ideas to the top three. These three ideas will later be narrowed down to their top idea. Encourage students to pursue multiple avenues until session five, when all information will be shared and building will begin.

2. **Team Planning:** One of the most important parts of any project is developing a plan that will help guide the team to completion. What are important aspects to include in a plan? The instructor should have examples of project plans to share with the students. The team should review and revise the team plan at the start and end of each meeting – a plan is not a rigid document and should be changed. See “Additional Materials” for team planning form.
   - Teams should be given about 20 minutes to put together a basic team plan. This should include identifying tasks, assigning perceived/planned tasks, creating team rules and expectations, and putting together a project time-line.
   - Teams should refer to their contract from session two as they put together the team plan.

3. **Team Research:** Teams should begin discussing the information they learned from their introductory research. They should share: answers to the questions in the book, interesting facts, questions they had, and interesting connections they made. From the discussion, teams should begin to assemble and group information for their exhibit, dig further into certain aspects of their research, and adjust their team plan.
Session 5: (50 minutes)

1. **Exhibit Design**: Introduce a few basic principles of exhibit design: contrast, repetition, alignment, and proximity, to help students with their layouts. Give examples of good and poor designs and have students critique them as a class.

2. **Labels**: A museum label is a caption describing an object exhibited, or a bulk of text that introduces a room, area, exhibit, or whole museum.
   - Three golden rules: (1) Be as brief as possible; (2) Make a point; (3) Use accessible language
   - Three perspectives to consider: (1) Content; (2) Style; (3) Design
   - Key themes:
     - Big Idea: this is not a topic, but what one says about them. It provides focus for both the visitor and the exhibition team. Always relate your exhibit pieces back to the big idea – what does this have to do with the big idea?
     - Objects and Audience: How are you going to grab the audience’s attention? How are you going to hold their attention? How long are they willing to give you their attention?
     - Messages and Meaning: Create ‘revelation through information’ (Freeman Tilden). Don’t describe; tell a story – but don’t write a book. Create a pyramid that works from the crucial to the not-so-crucial and identify the information with different fonts, bullets, bolding, etc. An analogy for the exhibit visitor: paddlers, swimmers, and divers.
   - Mini team challenge: Write a label to make an everyday object interesting, but you may only use 75 words or less.

3. **Review of Initial Exhibit Concept**: By the end of the fifth session teams should turn in an explanation of their exhibit concept. They should state their analogy, describe the analogy, and explain how their exhibit will be interactive or what moveable pieces their exhibit will have. They should also include a “budget” – a list of their anticipated materials – and their project plan for session six and onward.

Session 6-10: (50 minutes each)

1. **Expectations for Building**: Sessions six through ten will be geared toward the creation of the exhibit. Instructors should introduce their basic expectations during this process, such as:
   - All members of the team must be actively involved in some aspect of the exhibit building process including the creation of the model, display of the information, creation of labels, etc.
   - All work spaces must be clean by the end of each session and all materials must be stored in appropriate locations.
   - Only take those materials and tools that are going to be actively used. When something is not being used return it to the table for other teams.
   - Exercise safety when utilizing all tools and take appropriate safety measures where necessary – gloves, goggles, etc.

2. **Safety Introduction**: If you provide wood-working tools, or tools that require a specific safety protocol introduce this at the beginning of session six. You may need to explain to groups how to use specific tools such as: miter box and saw, drills and drill bits, awls, knives, and other sharp tools. If you provide your students with wood, pipe, and other heavy construction materials make sure the appropriate tools are available. Additional parent volunteers are suggested if allowing students to utilize wood-working tools.

3. **Instructor’s Role**: During sessions 6-10 the instructor should be available for questions and mediation. The role of the instructor should be to guide students through leading questions and suggested resources. Instructors should reiterate that teams should revisit their plan at the start and end of each session.
Session 11: (50 minutes)
1. Concept Review: Each group will lay out their display in the assigned location and groups will be assigned to review up to three exhibits. Reviews should take place as short discussion sessions lasting no more than five minutes. The reviewing teams should ask questions, test working parts, and offer at least two “stars” and one “wish”. “Stars” are things that the reviewers like about the current exhibit, a “wish” is something the reviewers would like to see added, changed, or subtracted. The “stars” and “wishes” can be written down and left for the reviewees to read at the completion of the session.
2. Team planning: Provide about 20 minutes at the end of the session for teams to regroup and go over the notes left by other teams. They should discuss the notes and incorporate new ideas and concepts into their plan. Teams should be encouraged to also reflect on the teams that they reviewed, and borrow ideas that they liked.

Session 12-15: (50 minutes each)
1. Interpretation: Interpretation is how museums help visitors make sense of exhibits. Interpretation is a story, it is factual, and it is always a conversation. Therefore, interpretation guides need to provide factual information on the concepts and principles being presented, the story of the key message of the exhibit, and suggested questions to help engage visitors. See “Additional Materials” for a form interpretation guide.
2. Refinement: During the final four sessions teams should refine their exhibits, complete all pieces of their display and assemble everything. By the close of session 15 teams should be completely finished with their exhibit.
3. Instructor’s Role: During sessions 12-15 the instructor should be available for questions and mediation. The role of the instructor should be to guide students through leading questions and suggested resources. Instructors should reiterate that teams should revisit their plan at the start and end of each session.

Session 16-17: (50 minutes each)
1. Exhibit Walk: Teams should be given about 10 minutes to complete any last minute set-up of their exhibit – it should not include building, but just adjustments and team planning for the interpretation. Each team should split into pairs with one pair visiting exhibits and the other remaining at their exhibit to interpret. The pairs will switch during the second session to allow all team members the opportunity to experience the exhibits and interpret.
2. Exhibit Walk Expectations: The instructor should set expectations for the individuals completing the exhibit walk including time spent at each exhibit, systematic gathering of information, a review of other teams’ exhibits, etc.
3. Evaluation: The Exhibit Walk period will give the instructor the opportunity to evaluate the teams on the criteria of the project. See “Additional Materials” for a suggested rubric and scoring system.

Session 18: (50 minutes)
1. Discussion: Engage the class in a discussion of their experience and knowledge acquired regarding scientific concepts, designing, team dynamics, and project planning.
2. Evaluation: Teams should be given an opportunity to review themselves, their teams, and their team members. Provide a rubric that allows each student to review these aspects of the project and a space to reflect on the experience. See “Additional Materials” for suggested formats for both a rubric and a self-assessment.
Additional Materials
PROJECT OVERVIEW

Analogous Model Museum Exhibit Design Challenge

SCENARIO:
The Tech Museum of Innovation in San Jose, California is building a new exhibit and needs ideas for new, interactive displays. The exhibit is an exploration of anatomy, physiology, and development. In order to make the exhibit accessible to individuals with little-to-no science knowledge, they would like the displays to include interactive and hands-on analogous models.

CHALLENGE:
Design and build a museum exhibit/display that includes labels, an analogous device/model, and an exhibit interpretation guide based on an assigned human body system.

CONSTRAINTS:
• Your device must have at least one (1) moveable part and be able to withstand repeated but gentle use by other students.
• You must make a drawing of your device and have it approved by the instructor before you start to build.
• No pre-built parts or devices may be utilized.
• You must include a display board or partitioning device to display information and keep your display separate from others.
• The display must fit in a 2.5’ x 2’ space.
• All pictures and information must be appropriately cited.
• Everyone on the team must contribute to the exhibit/display.
• All labels must be original work. No plagiarism.

MATERIALS AND RESOURCES:
• Various art and construction supplies from the classroom or from home may be utilized. No pre-built models are allowed.
• You will have access to computers with internet resources.
• You are encouraged to utilize the class science text and other books that you find both inside and outside of class.

PROJECT TIMELINE:

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<th>Topic</th>
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<td>Session 2</td>
<td>Teams and Topics Assigned. Establish Team Expectations. Begin Research.</td>
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<td>Session 3-4</td>
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<td>Initial Concept Review Due. Review of Exhibit Design and Labels.</td>
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<tr>
<td>Session 18</td>
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Skeletal System
Student Handout

VOCABULARY:
- Skeletal system
- Compact bone
- Spongy bone
- Cartilage
- Joint
- Ligament
- Mechanical advantage

OBJECTIVES:
1. Identify the major organs of the skeletal system.
2. Describe the functions of bones.
3. Illustrate the internal structure of bones.
4. Compare (and contrast) 3 types of joints.
5. Discuss how bones function as levers.

STANDARDS:
1. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Students know:
   a. Plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
   b. Organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
   c. How bones and muscles work together to provide a structural framework for movement.
2. Physical principles underlie biological structures and functions. Students know:
   a. How to compare joints in the body (wrist, shoulder, thigh) with structures used in machines and simple devices (hinge, ball-and-socket, and sliding joints).
   b. How levers confer mechanical advantage and how the application of this principle applies to the musculoskeletal system.
3. Scientific progress is made by asking meaningful questions and conducting careful investigations.
   a. Select and use appropriate tools and technology to perform tests and to collect and display data.
   b. Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.
   c. Communicate the logical connection among hypotheses, science concepts, and tests conducted, data collected, and conclusions drawn from the scientific evidence.
   d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.
   e. Communicate the steps and results from an investigation in written reports and verbal presentations.
VOCABULARY:

- Muscular system
- Smooth muscle
- Cardiac muscle
- Skeletal muscle
- Tendon
- Flexor
- Extensor

OBJECTIVES:

1. List the major parts of the muscular system.
2. Describe the different types of muscle.
3. Describe how skeletal muscles move bones.
4. Compare (and contrast) aerobic exercise with resistance exercise.

STANDARDS:

1. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Students know:
   a. Plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
   b. Organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
   c. How bones and muscles work together to provide a structural framework for movement.
2. Scientific progress is made by asking meaningful questions and conducting careful investigations.
   a. Select and use appropriate tools and technology to perform tests and to collect and display data.
   b. Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.
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   d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.
   e. Communicate the steps and results from an investigation in written reports and verbal presentations.
Integumentary System

Student Handout

VOCABULARY:

• Integumentary system
• Sweat glands
• Melanin

• Epidermis
• Dermis
• Hair follicle

OBJECTIVES:

1. Describe the major functions of the integumentary system.
2. List the major parts of the skin, and discuss their functions.
3. Describe the structure and function of hair and nails.
4. Describe some common types of damage that can affect skin.

STANDARDS:

1. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Students know:
   a. Plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
   b. Organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
2. Scientific progress is made by asking meaningful questions and conducting careful investigations.
   a. Select and use appropriate tools and technology to perform tests and to collect and display data.
   b. Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.
   c. Communicate the logical connection among hypotheses, science concepts, and tests conducted, data collected, and conclusions drawn from the scientific evidence.
   d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.
   e. Communicate the steps and results from an investigation in written reports and verbal presentations.
Cardiovascular System

Student Handout

VOCABULARY:

- Cardiovascular system
- Blood
- Plasma
- Platelet
- Atrium
- Ventricle
- Arteries
- Capillaries
- Veins
- Pulmonary circulation
- Systemic circulation
- Blood pressure

OBJECTIVES:

1. Describe the functions of the cardiovascular system.
2. Compare and contrast the 3 types of blood vessels.
3. Describe the path that blood travels as it circulates through the body.
4. Distinguish between blood types.

STANDARDS:

1. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Students know:
   a. Plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
   b. Organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
2. Contraction of the heart generates blood pressure, and heart valves prevent backflow of blood in the circulatory system.
3. Scientific progress is made by asking meaningful questions and conducting careful investigations.
   a. Select and use appropriate tools and technology to perform tests and to collect and display data.
   b. Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.
   c. Communicate the logical connection among hypotheses, science concepts, and tests conducted, data collected, and conclusions drawn from the scientific evidence.
   d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.
   e. Communicate the steps and results from an investigation in written reports and verbal presentations.
VOCABULARY:

- Lymphatic system
- Lymph capillaries
- Lymph
- Lymphatic vessels
- Lymph nodes
- Thymus
- Spleen
- Tonsils

OBJECTIVES:

1. Discuss the functions of the lymphatic system.
2. Identify the relationship between lymph and blood.
3. Describe the organs of the lymphatic system.

STANDARDS:

4. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Students know:
   a. Plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
   b. Organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
5. Scientific progress is made by asking meaningful questions and conducting careful investigations.
   a. Select and use appropriate tools and technology to perform tests and to collect and display data.
   b. Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.
   c. Communicate the logical connection among hypotheses, science concepts, and tests conducted, data collected, and conclusions drawn from the scientific evidence.
   d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.
   e. Communicate the steps and results from an investigation in written reports and verbal presentations.
Respiratory System

Student Handout

VOCABULARY:

- Respiration
- Respiratory system
- Pharynx
- Larynx
- Trachea
- Bronchi
- Alveoli
- Diaphragm
- Cellular respiration

OBJECTIVES:

1. Describe the flow of air through the respiratory system including cellular respiration.
2. Discuss the relationship between the respiratory system and circulatory system.
3. Identify respiratory disorders.

STANDARDS:

1. A typical cell of any organism contains genetic instructions that specify its traits. Those traits may be modified by environmental influences.
2. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Students know:
   a. Plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
   b. Organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
   c. How bones and muscles work together to provide a structural framework for movement.
3. Scientific progress is made by asking meaningful questions and conducting careful investigations.
   a. Select and use appropriate tools and technology to perform tests and to collect and display data.
   b. Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.
   c. Communicate the logical connection among hypotheses, science concepts, and tests conducted, data collected, and conclusions drawn from the scientific evidence.
   d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.
   e. Communicate the steps and results from an investigation in written reports and verbal presentations.
**VOCABULARY:**

- Nervous system
- Central nervous system
- Peripheral nervous system
- Neuron
- Impulse
- Dendrite
- Axon
- Sensory neuron
- Receptor
- Motor neuron
- Nerve
- Brain
- Cerebrum
- Cerebellum
- Medulla
- Reflex

**OBJECTIVES:**

1. Explain how neurons in the nervous system work together.
2. Compare and contrast the central nervous system and the peripheral nervous system.
3. Describe the major functions of the four parts of the brain and the spinal cord.

**STANDARDS:**

1. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Students know:
   a. Plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
   b. Organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
2. Scientific progress is made by asking meaningful questions and conducting careful investigations.
   a. Select and use appropriate tools and technology to perform tests and to collect and display data.
   b. Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.
   c. Communicate the logical connection among hypotheses, science concepts, and tests conducted, data collected, and conclusions drawn from the scientific evidence.
   d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.
   e. Communicate the steps and results from an investigation in written reports and verbal presentations.
Five Senses  
(Part of the nervous system)  
*Student Handout*

**VOCABULARY:**

- Retinal
- Photoreceptors
- Rods
- Cones
- Optic nerve
- Iris
- Lens
- Chochlea

**OBJECTIVES:**

1. Describe the 3 sensations that are detected by receptors in the skin.
2. Describe how light relates to vision and explain the functions of the rods and cones.
3. Explain how the ear works.
4. Explain how taste and smell are connected.

**STANDARDS:**

1. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Students know:
   a. Plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
   b. Organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
   c. How to relate all the structures of the eye and ear to their functions.
2. Physical principles underlie biological structures and functions. Students know:
   a. For an object to be seen, light emitted by it or scattered from it must enter the eye.
   b. Light travels in straight lines except when the medium it travels through changes.
   c. How simple lenses are used in magnifying glass, the eye, a camera, telescope, and microscope.
   d. White light is a mixture of many wavelengths (colors), and that retinal cells react with differently with different wavelengths.
3. Scientific progress is made by asking meaningful questions and conducting careful investigations.
   a. Select and use appropriate tools and technology to perform tests and to collect and display data.
   b. Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.
   c. Communicate the logical connection among hypotheses, science concepts, and tests conducted, data collected, and conclusions drawn from the scientific evidence.
   d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.
   e. Communicate the steps and results from an investigation in written reports and verbal presentations.
Endocrine System
Student Handout

VOCABULARY:

- Endocrine system
- Gland
- Hormone
- Feedback control
- Pituitary gland
- Thyroid gland
- Pancreas
- Adrenal glands
- Ovary/testis

OBJECTIVES:

1. Explain the function of the endocrine system.
2. Illustrate the locations of the endocrine glands in the body and list their functions.
3. Describe how feedback controls stop and start hormone release.

STANDARDS:

1. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Students know:
   a. Plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
2. Scientific progress is made by asking meaningful questions and conducting careful investigations.
   a. Select and use appropriate tools and technology to perform tests and to collect and display data.
   b. Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.
   c. Communicate the logical connection among hypotheses, science concepts, and tests conducted, data collected, and conclusions drawn from the scientific evidence.
   d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.
   e. Communicate the steps and results from an investigation in written reports and verbal presentations.
VOCABULARY:

- Sexual reproduction
- Egg
- Sperm
- Zygote
- Internal fertilization
- Placental mammal
- Testes
- Scrotum
- Sperminiferous tubules
- Epididymis
- Vas deferens
- Semen
- Puberty
- Urethra
- Penis
- Ovaries
- Ovulation
- Fetus
- Fallopian tubes
- Uterus
- Vagina
- Menstruation
- Infertile
- Sexually transmitted disease
- Embryo
- Implantation
- Placenta
- Umbilical cord

OBJECTIVES:

6. Distinguish between: a) external and internal fertilization, and b) asexual and sexual fertilization.
7. Describe the 3 different types of mammalian development.
8. Describe the functions of the male and female reproductive systems and summarize the process of fertilization and implantation.
9. Describe the course of human development.

STANDARDS:

6. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Students know:
   a. Plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
7. Scientific progress is made by asking meaningful questions and conducting careful investigations.
   a. Select and use appropriate tools and technology to perform tests and to collect and display data.
   b. Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.
   c. Communicate the logical connection among hypotheses, science concepts, and tests conducted, data collected, and conclusions drawn from the scientific evidence.
   d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.
   e. Communicate the steps and results from an investigation in written reports and verbal presentations.
# Team Contract

*Expectations and Consequences for Team Members*

Class: ______________

Project Name: ______________  Project Duration: ______________

## Group Member Information

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone Number</th>
<th>Does teammate have a computer at home or a laptop?</th>
<th>Does teammate have access to the Internet?</th>
<th>When can teammate meet outside of school hours?</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

## Strengths and Weaknesses:

List for each team member their self-assessed strengths and areas for improvement, as well as the type of learner with which they identify.

<table>
<thead>
<tr>
<th>Name</th>
<th>Learner Type (visual, auditory, kinesthetic, mixed)</th>
<th>Content Strengths</th>
<th>Technical Strengths</th>
<th>Areas of Improvement</th>
</tr>
</thead>
<tbody>
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</table>

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**Team Agreements and Ground Rules:** Identify the rules by which the team will operate. This includes how you interact with each other, how work will be distributed, how conflict will be managed, how decisions will be made, etc.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Agreements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal Interactions</strong></td>
<td>Example: Teammates will give full opportunity to others to share their ideas and opinions.</td>
</tr>
<tr>
<td><strong>Distribution of Work</strong></td>
<td>Example: Work will be distributed first on a volunteer basis, and then based on self-identified strengths.</td>
</tr>
<tr>
<td><strong>Conflict Management</strong></td>
<td>Example: All personal conflicts will be resolved outside of team meetings, with a third member present for mediation.</td>
</tr>
<tr>
<td><strong>Making Decisions</strong></td>
<td>Example: Decisions will be made by a simple majority vote.</td>
</tr>
<tr>
<td><strong>Other</strong></td>
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<tr>
<td><strong>Other</strong></td>
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</tbody>
</table>
Content Knowledge Accountability: In addition to completing our project work, we must also demonstrate proficiency in the standards for the course in order to receive credit. Our group agrees to take the specific steps listed below, and to use the strategies also listed to ensure that ALL group members learn the content knowledge and standards embedded in this project.

1.
2.
3.
4.

Conflict Resolution Procedure: In accordance with the agreements listed above, we agree to take the following specific steps in the mitigation of all conflicts whether they are difficulties addressing the specific tasks and/or working with each other (e.g. content, internal conflict). We expect the instructor or classroom facilitator to also take the specific steps listed below to help get the group “back on track.”

1.
2.
3.
4.

Group Temperature Check: Below is a table that your group should use regularly to record and monitor your group's successes and difficulties. All difficulties (conflicts, issues, problems, etc.) must be documented prior to seeking mitigation help from the instructor or class facilitator.

<table>
<thead>
<tr>
<th>Teammate</th>
<th>Summary of Success</th>
<th>Date</th>
<th>Witness Initials</th>
</tr>
</thead>
<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Teammate</th>
<th>Summary of Difficulty</th>
<th>Date</th>
<th>Witness Initials</th>
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</tbody>
</table>
Roles and Responsibilities: Following are some questions your group may want to address while assigning roles and responsibilities to your various group members.

1. Who will check the final product against the Rubric?
2. Who will check to make sure all content has proper citations?
3. Who will proofread all work for spelling and grammar and check of any calculations?
4. Who will be in charge of ensuring all group members are prepared for the presentation?
5. Who will be in charge of creating the final documents to turn into the instructor?
6. Who will be in charge of ensuring the team stays on topic and that the team’s schedule is met?

Group Rules: Your group may want to consider the following categories and questions when establishing your group rules.

1. Absence Policy - Will points be deducted for missing days of school? What expectations does your group have for group members that miss a session?
2. Work Policy - What happens when a group member does not finish their share of the work or the work is late? Are there any exceptions to the rules you are setting?
3. Project Points - How will the points be divided among team members? How can a member lose points? Is it possible to earn points back?

Group Member Dismissal: Does your group want to have a policy regarding group member dismissal should any member of the group not perform their tasks as specified in this contract? If so, these are the policies your group must follow:

1. First Written Warning - establish what leads to the first warning. What will be the consequences/plan/strategy used to help the group member avoid a second warning?
2. Second Written Warning - establish what leads to a second warning. What will be the consequences/plan/strategy used to help the group member avoid a third warning?
3. Third Warning - Meeting with the instructor.
4. Dismissal from group - upon dismissal group member is entitled to group products leading up to dismissal date, but all future work must be completed as an individual. Individuals dismissed from the group may not form or join another group.

Miscellaneous Items: In the space provided below, the team may include any other items that the group agrees should be in the contract based on previous collaboration experiences and the requirements of the project.

Team Signatures: We, the undersigned, agree that we were fully present in the making of this document, had equal voice in finalizing this document, and will uphold the agreements herein. We also agree to revisit this document regularly and to use this document to guide our group decisions.

_______________________  _____________________  _____________________

_______________________  _____________________  Date: __________

Instructor's Signature: ___________________________  Date: __________
Brainstorming Guidelines for Teams

Brainstorming is a method of shared thinking, where everyone in a group quickly calls out their idea for a solution or possible answer.

Some basic rules will help the brainstorming sessions be effective:

- No criticism allowed: all ideas are welcome. Do not judge ideas at this stage.
- Work for quantity: the more ideas, the better. Write them all down.
- Hitchhiking is welcome: people can often build on (modify, expand) each other’s ideas.
- Outrageous ideas are encouraged: often those crazy ideas have some hint that will help solve the problem.

Scamper is another technique that can help teams come up with new ideas or modify those they already have. Use these words to come up with questions that can help you to brainstorm ideas. For example, “Is there a way that we can combine this idea with that idea to come up with a better idea?”

Substitute: Have a person or thing act or serve in place of another. What can you substitute? What material or process can you use instead?

Combine: Bring things together. What can be blended, mixed, included? What ideas or parts can you combine?

Adapt: Adjust something in order to suit a specific condition or purpose. What should I copy? How can this be modified for other uses?

Modify/Magnify/Minify: What can you make bigger or smaller? How can you make it longer, stronger, heavier, lighter, etc.?

Put to other uses: Use something for purposes other than originally intended. Does it shape, form, or material suggest other uses?

Eliminate: What can we do without? What if we left out certain parts?

Reverse: What if you reverse it? Turn it upside down? Turn it inside out?

The team should always have someone taking notes during a brainstorming session. These notes should be kept in the design journal. You never know when you might want to look at them again!

Project Plan

Revision Date: ______

Team Name: __________________________

Assigned Topic: ______________________

Analogous Model Design Sketch: Use the provided area to sketch and label your analogous model design. Your labels should include information regarding materials, quantities, and measurements.
Exhibit Display Layout Sketch: Use the provided area to sketch and label your layout for your exhibit display. Your labels should include information regarding materials, quantities, and measurements.
Explanation of Design: Use the space provided to explain your design choices and an explanation of your analogy.

Materials List: Use the following table to list the materials needed for your exhibit as well as how the materials will be used, and the source of the materials. If the materials will need to be purchased include the price. You will also want to include in your list the tools you expect to use.

<table>
<thead>
<tr>
<th>Material/Tool</th>
<th>For</th>
<th>Source</th>
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</table>
**Project Schedule:** A gantt chart is a bar chart that easily illustrates a project schedule. Bars are used to illustrate the start and finish dates of different elements of a project. In the left hand column list the different project elements. The top row lists the different sessions. For each element listed in the left hand column shade the anticipated number of sessions it will take to complete. You may also use this chart to assign elements to different team members. Some of the summary elements of your project have already been included to provide you with a point of reference your “terminal elements” or the elements that help break down the structure of your project (ex. write text, cut pieces, etc.)

<table>
<thead>
<tr>
<th>Element</th>
<th>Duration (Sessions)</th>
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<th>2</th>
<th>3</th>
<th>4</th>
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<th>6</th>
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<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
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<tbody>
<tr>
<td>Brainstorming and Researching</td>
<td>5 Sessions</td>
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<tr>
<td>Building Model and Display</td>
<td>10 Sessions</td>
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<tr>
<td>Prepare Museum Interpretation Guide</td>
<td>4 Sessions</td>
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</table>
Interpretation Guide

Team Name: __________________________     Assigned Topic: ________________________

What is your human body system?
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

What is your analogy?
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

Describe your model:
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

How does your model work?
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

What is the overarching theme of your display? What should visitors take away with them?
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

Key points:
1. __________________________________________________________________________________
2. __________________________________________________________________________________
3. __________________________________________________________________________________
Useful Vocabulary:

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
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</tbody>
</table>

How do visitors interact with your model and display?

_____________________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________________

Open-ended questions to help guide visitor's learning:

1. __________________________________________________________________________________________________________________________

2. __________________________________________________________________________________________________________________________

3. __________________________________________________________________________________________________________________________

4. __________________________________________________________________________________________________________________________

5. __________________________________________________________________________________________________________________________
Design Challenge Reflection

Name: _____________________________  Team Name: __________________________

1. What factors were important to consider when designing your model?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

2. What aspect of your system did your model demonstrate?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

3. How well did your model demonstrate that aspect?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

4. How would you change or improve your model?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

5. How would you change or improve your display?
   __________________________________________________________________________

6. As a group, did we all share?  
   Yes  Sometimes  No

7. Did we take turns?  
   Yes  Sometimes  No

8. Did everyone contribute to the model?  
   Yes  Sometimes  No

9. Did everyone contribute to the display?  
   Yes  Sometimes  No

10. Did we listen to each other?  
    Yes  Sometimes  No

11. Did we help each other?  
    Yes  Sometimes  No
## Analogous Models

### Design Challenge Learning

<table>
<thead>
<tr>
<th>Research and interpretation of science content</th>
<th>1 Point</th>
<th>2 Points</th>
<th>3 Points</th>
<th>4 Points</th>
<th>5 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little to no research was completed or documented.</td>
<td>Some research was completed but only one source was utilized.</td>
<td>Research across several sources was documented with little to no interpretation.</td>
<td>Research across several sources was well documented. Students interpreted the information.</td>
<td>Extensive research across a variety of sources was well documented. Students made connections and interpreted information.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Model shows a clear analogy with at least one moveable part</th>
<th>1 Point</th>
<th>2 Points</th>
<th>3 Points</th>
<th>4 Points</th>
<th>5 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>It has a dubious analogy, no moveable part, and imparts little information.</td>
<td>It has a dubious analogy, one moveable part and imparts minimal information.</td>
<td>It has one moveable part, a moderate analogy that imparts general information.</td>
<td>It has one or more moveable parts, a good analogy that imparts basic information.</td>
<td>It has two or more moveable parts, a clear analogy that imparts additional information.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clear and thorough documentation of the design process and final project</th>
<th>1 Point</th>
<th>2 Points</th>
<th>3 Points</th>
<th>4 Points</th>
<th>5 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teams maintained documents related to their project plan that were almost entirely incomplete.</td>
<td>Teams maintained documents pertaining to their project plan. Documents are incomplete.</td>
<td>Teams maintained complete documents pertaining to their project plan but were never revised/revisited.</td>
<td>Teams maintained project plans that were complete and were seldom revised/revisited.</td>
<td>Teams maintained project plans that were complete and revised/revisited often.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Overall Quality of Exhibit</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Accurate</td>
<td>Engaging</td>
<td>Vocabulary</td>
<td>Design</td>
<td>Big Idea</td>
<td></td>
</tr>
<tr>
<td>The exhibit lacks all of the following: clear ideas, accuracy, &amp; vocabulary, but is engaging. It has many errors, and craftsmanship is poor.</td>
<td>The exhibit lacks two of the following: clear ideas, accuracy, &amp; vocabulary, but is engaging. It has many errors. Craftsmanship is poor.</td>
<td>Exhibit lacks either clear ideas, vocabulary, or accuracy, and is not very engaging. It has several errors. Craftsmanship is adequate/acceptable.</td>
<td>The exhibit has ideas that are not quite clear or not entirely accurate. It is engaging, includes vocabulary and has few errors. Craftsmanship is good.</td>
<td>The exhibit has very clear ideas, is accurate, and is very engaging. It has additional vocabulary &amp; few or no errors. Craftsmanship is excellent.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Overall Interpretation</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation does not have structure; model easily breaks; does not command attention or have good eye contact.</td>
<td>One of the 5 are done well and at least 2 are done moderately well.</td>
<td>Two or 3 are done well and 2 are done moderately well.</td>
<td>Four are done well and the 5 th is done moderately well.</td>
<td>All 5 are done well.</td>
<td></td>
</tr>
</tbody>
</table>

Possible Score: _____ 100 
Score: _____ x 4 = _______ Total Score