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| **Title**  | The “Heart” of the Jungle: Looking at Cardiovascular problems in humans and great apes.  |
| **Introduction**  | We all know that gorillas and humans are alike in many ways, but few know that one of these ways is our common problems with heart health. Cardiovascular disease affects humans and great apes in a similar percent of the population as well as in similar ways. Heart disease is a major cause of mortality in both humans and great apes. Right now both humans and great apes are being treated and monitored by cardiologists, engineers and other specialists to find ways to prevent, treat, and cure cardiovascular problems with both species. In this problem based lesson students will analyze the cardiovascular health of humans and compare health risks shared by humans and great apes (specifically gorillas). Students will then study advancements in human cardiovascular health monitoring techniques and follow the engineering design process through the ideation stage to develop a cardiovascular health monitoring wearable device for great apes. This lesson is based around an open ended problem that is currently being researched in the field, as such, much of the responsibility of learning is placed on the student. Classroom sessions are structured around exposing students to state of the art techniques for cardiovascular health monitoring and developing student research and data analysis skills.  |
| **Real Science Application**  | Comparing human health data to data from great apes may be used to determine different risk factors that make both species susceptible to cardiovascular problems. Cardiovascular health monitoring has become an increasingly populated field of study and technology development in recent years. Current studies in the field of wearable technology (check out the link to NC State’s ASSIST center in the references section) are working towards developing new less invasive and/or less restrictive methods of cardiovascular health monitoring. Progress in this field includes less restrictive electrocardiogram (ECG) technology as well as reliable heart rate monitors. Ideally advancements in cardiovascular health monitoring will result in patients being able to monitor their own cardiovascular health daily and doctors and researchers having reliable data collected over time in a person’s regular environments. Student ideation should produce ideas that will solve similar problems that real world research is attempting to solve. Students will be exposed to the same real world engineering methods used by state of the art researchers.  |
| **Curriculum Alignment**  | This section contains the curriculum alignment of the lesson to the North Carolina [NC Essential Standards](http://www.ncpublicschools.org/acre/standards/new-standards/) of Science or Math, and the [Next Generation Science Standards](http://www.nextgenscience.org/next-generation-science-standards) (NGSS) or [Common Core Math](http://www.corestandards.org/Math/).

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| Content Area | Grade Level | NC Essential Standards | NGSS / Common Core Math |
| Science | 7th | 7.L.1 Summarize the general functions of the major systems of the human body (circulation) and the way that these systems interact with each other to sustain life.  |  |
| Science | 8th  | 8.L.4.1 Summarize the use of evidence drawn from comparative anatonmy to for the basis for biological classification systems and the theory of evolution.  |  |
| Science | 6-8 |  | MS-PS1-3 Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. |
| Science | 6-8 |  | MS-PS2-1 Apply scientific ideas or principles to design an object, tool, process or system. |
| Science  | 6-8 |  | MS-ETS1-1 The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. |
| Science | 6-8 |  | MS-ETS1-4 Models of all kinds are important for testing solutions. |

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| **Learning Outcomes**  | * Students will be able to summarize common cardiovascular risks facing both humans and great apes.
* Students will be able to explain and utilize the engineering design process when solving open ended problems.
* Students will be able to ideate a prototype monitoring device to monitor gorilla cardiovascular health based on state of the art sensor technology.
* Students will be able to distinguish problems facing the engineering design of cardiovascular health monitoring systems that are specific to humans or gorillas.
* Students will be able to discuss why problems facing health monitoring are exclusive to each species.
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| **Time Required and Location**  | 5 days, 60 minute class periods within a classroom.  |
| **Materials Needed**  | **Teacher List-** * Electrocardiogram and electrodes (preferably enough to monitor at least one student per group, if not enough to monitor the teacher)
* Pulse Monitor
* Project Rubric
* Projector to allow students to present

**Student List-** * Copy of article “Why do zoo apes get heart disease?” (1 per student)
* 1 computer per every 2 students
* Student worksheet “State-of-the-Heart” (1 per student)
* Student project assignment sheet “The ‘Heart’ of the Jungle” (1 per student)
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| **Safety**  | There should be no safety concerns specific to this lesson; however if a student wishes to monitor their own ECG or heart rate it should be made clear to both students and parents that data collected in the classroom is not medically significant and monitoring is voluntary.  |
| **Student Prior Knowledge**  | This lesson is meant to fit within a comparative anatomy 8th grade unit, a 7th grade human body systems unit, or a 7th or 8th grade engineering design process unit; therefore it is assumed that students know the basic functions of the human heart and the overall process of the circulatory system as well as the engineering design process and computer research skills. For more information on the engineering design process look at the Next Generation Science Standards Website- <http://www.nextgenscience.org/next-generation-science-standards> )  |
| **Teacher Preparations**  | Be familiar with how to operate the ECG monitoring device.Prepare computer access for students on research days. Be familiar with easy techniques for students to monitor their own heart rateReview sources in the references section of this lesson to become familiar with state of the art monitoring techniques for cardiovascular problems and current systems that monitor gorilla heart health. Preview research articles and websites provided. Put students into groups of 4-5. Have students register for free emaze.com and/or prezi.com accounts if possible.  |
| **Activities**  | **Day 1- Humans and Great Apes Introduction****Engage-** Begin class by asking students to write down things that humans have in common with great apes like chimpanzees, orangutans, and gorillas as well as things that differ between humans and great apes. Discuss answers as a class (answers will vary greatly, try to have students narrow in on physiological similarities and differences) [5-7 minutes] **Explore-**  Have students read and annotate the article “Why do zoo apes get heart disease?” (<http://www.bbc.co.uk/nature/17542031>). As students finish early have them write down a summary of the article and at least 5 extension questions they would like to ask zoologists, cardiologists, and other researchers in the fields of human and animal cardiovascular health. [approx.. 30 minutes] When students have finished reading, annotating, and responding have them discuss their thoughts on the article and share the questions they would like to ask as a group. Each group should then narrow down their thoughts into 3 final questions for researchers they generate as a group. [5-7 minutes]**Explain-** Have a student summarize the article to the class, then have at least one other student in the class add detail to their summary. Ask each group to share their questions and as the groups share questions type the questions into a word document that is projected in the front of the room for all students to see. After each group has shared explain to students that these are the questions that they will now be researching in order to help develop a monitoring system to evaluate the cardiovascular health of great apes. [approx. 10 minutes]**Elaborate-** “Snowball Exit” Have students spend 5 minutes responding to the following questions on a piece of paper and then before they leave crumple the paper up into a “snowball” and throw it into a box or basket at the front of the room. 1. Why might we want to study the cardiovascular health of gorillas and other great apes?
2. What [possible difficulties might arise if you try to use the same cardiovascular health monitors on humans and apes?
3. List at least 3 things you MUST consider if you’re creating a wearable device like a wristband or chest strap for a great ape.

[10 minutes]**Day 2- Exploring Pulse and ECG Monitoring****Engage-**  Have students begin class by responding to the prompt: “Joe seems like a healthy guy but recently his chest has been feeling “tight” and his heart has been beating really fast during times when he should be calm, what do you believe might be going wrong? How would you describe his symptoms to a doctor using scientific vocabulary?” Have students share their answers with a partner at their table and then write down on a blank sheet of paper or small whiteboard common scientific vocabulary both partners used in their answers. Once groups have finished count to three and have students hold up their paper or whiteboard. Students should look around and see what common vocabulary is found across the classroom and what vocabulary differs. [7-10 minutes] **\*\*The Explain and Explore steps will happen concurrently while students complete the explain process on their own and the explore step happens with student guidance\*\* [40 minutes]****Explain-** Students should work on computers or laptops in pairs (or individually if possible, whichever you prefer) to research information about ECGs and Heart Rate monitors. As students learn about ECG and heart rate monitoring they should fill out the worksheet “State-of-the-Heart” either digitally or on paper. To help explain what an ECG is students can watch this video (<https://www.youtube.com/watch?v=SNrTbeL2h84>). While researching have students pay special attention to “.edu” links as they will be the most likely to contain collegiate level research. Students should easily be able to find sources in the news for new developments in both ECGs and Pulse monitors. **Explore-**  At a central point in the room the teacher should have the ECG and pulse monitor set up for students to explore. If you can obtain enough electrodes to test at least one student in each group then have one (or more depending on materials available) student place the electrodes on their wrists and show students how the ECG is monitored. Have students test their pulse using the monitor and/or by placing two fingers against their carotid artery at the base of their neck and count the beats for 15 seconds and then multiply that number by 4 to determine the beats per minute of their heart. If students are measuring their pulse using their fingers explain to students that pulse monitors do essentially the same thing it just counts beats electronically. **Elaborate-** For the last 5-10 minutes in class have students brainstorm with their group what techniques that they saw today to monitor ECG and heart rate that might be able to be applied to gorillas. Have each group of students determine and record the top three things they saw that might be able to extend to gorillas and the top three things that would not work for gorillas. One student from each group should record their group’s answers on a padlet or google doc to share with the class. [5-10 minutes]**Day 3- Engineer an solution****Engage-**  Have students begin class by writing down the steps to the engineering design process and respond to the question, “what is the most important step in the engineering design process?” Students should share their answer with their group and then have a brief class discussion of the steps of the engineering design process. [5-7 minutes]\*\*If students have not gone over the engineering design process previously you can change the question to “what is the most important step in creating a new product?”\*\***Explore-** Teacher should distribute a project sheet to each student or post project guidelines online where students can access requirements. Students should follow the steps of the engineering design process in order to develop a cardiovascular health monitoring system for a gorilla that monitors either the gorilla’s ECG or heart rate (ambitious groups can feel free to do both). Students should identify the problem and then list constraints as a group- before moving onto ideation the problem and constraints must be approved by the teacher who will circulate and assist students in handling the open-ended nature of this problem. Each student group’s design idea must meet the following criteria: * Must be wearable by a gorilla for at least 24 hours at a time
* Must be durable enough to remain functioning while the gorilla wears it.
* Must be comfortable for the gorilla
* Must be able to monitor ECG and/or pulse automatically (no buttons need to be pressed etc.)

 To assist student’s, the design process criteria should be posted on a wall or projected onto a surface. [50 minutes]**Explain-**  Students should begin completing a reflection on the engineering design process at the end of this day. Their reflection requirements are outlined on the project sheet, be sure to remind students that the reflection accounts for the majority of their grade on this project. [5-7 minutes]**Day 4- Finalize idea and prepare to present****Explore-** Students should work with their group to finalize design plans and have final designs approved by the teacher. Once final plans are designed students should create their presentation using either emaze.com or prezi.com. Both emaze.com and prezi.com require an account but both have free registration. Teacher should circulate and help students to create their presentation and make sure that students are preparing for their presentations using the rubric and the requirements on their project sheet. **Day 5****Evaluation of learning defined in Assessment section below.**  |
| **Assessment**  | **Evaluate-** On the final day of this lesson students should present their ideation to the rest of their class using the presentation they created either using Prezi or Emaze. Remind students that when their group presents they should outline their purpose for creating their monitor as well as their design process. Each presentation should be between 4 and 6 minutes in length. While groups present have the rest of the students in the class write down at least four questions that they have about the group’s design. At the end of each group’s presentation allow for approximately 3-5 minutes of time where students ask the questions they had written down for the group.**Assessment-** Student projects should be graded based on the included project rubric. Each student will also be responsible for the reflection assigned to them. Both the presentation and the reflection should serve as one grade where the reflection accounts for 70% of a student’s total grade so that the majority of their grade is their own responsibility and only 30% of their grade depends on their group.  |
| **Critical Vocabulary**  | Cardiovascular- of or pertaining to the heart and vascular systemMonitor- to observe over timeElectrocardiogram (ECG)- a tool used routinely to assess the electrical and muscular functions of the heartHeart Rate- number of heart beats per minute, can help to determine the overall health of the heart |
| **Community Engagement** | There are several ways to incorporate the community into this lesson, bringing in doctors, veterinarians, zookeepers or local college animal science students or professors can be a great way to add real-world value to the assessment as well as a way for students to ask questions about the heart or gorillas to help them to better design their wearable device.  |
| **Extension Activities**  | If additional time is available this can continue into a discussion of comparative anatomy and physiology. Comparing gorilla bone structure and posture against human could be especially interesting. This could also be extended into a lesson comparing gorilla and human health to other animals in order to see genetic similarities and/or discuss zoonotic diseases.  |
| **Modifications**  | In order to address students who are learning English: * Utilize translation services and text-to-speech functions
* Look on sites like newsela.com which can adjust lexile levels on articles
* Have students work in groups with bilingual students or students who would be comfortable reading aloud to their group
* Provide research sources that are accessible and understandable to the student instead of requiring them to complete their own research

In order to address students with comprehension problems: * Look on sites like newsela.com which can adjust lexile levels on articles
* Shorten the article “Why do zoo apes get heart disease?” by eliminating interior paragraphs
* Allow students to utilize a student science dictionary to help with annotation
* Have students work in groups with students who would be comfortable reading aloud to their group
* Provide research sources that are accessible and understandable to the student instead of requiring them to complete their own research

In order to teach this lesson with limited technology: * Find and make copies of research articles to provide to the students
* Have students create their presentations on poster board instead of prezi.com or emaze.com
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| **Alternative Assessments**  | All students should be able to be graded for their participation in the group’s presentation; however modifications may be necessary for some students to complete the reflection portion of the assignment. Modified reflection questions can include several of the following: * How did your group work together to create your project?
* What problems did your group run into when creating your project?
* Why did your group design your project?
* Why is your project important?
* How would you try your project out on a real gorilla?
* What could make your project better?
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| **References**  | BBC Article “Why do zoo apes get heart disease?” - <http://www.bbc.co.uk/nature/17542031>LA Times Article about gorilla heart health- <http://latimesblogs.latimes.com/unleashed/2008/04/gorilla-heart-d.html>Smithsonian National Zoo Gorillas participate in heart study- <http://nationalzoo.si.edu/SCBI/AnimalCare/News/gorillastudy.cfm>Survey of wearable and wireless ECG monitoring- <http://www.ncbi.nlm.nih.gov/pubmed/23334714>NC State’s ASSIST center for wearable nanotechnology research- <http://assist.ncsu.edu> |
| **Supplemental Information**  | The Great Ape Heart Project is one of the world leaders in gorilla heart health research- <http://greatapeheartproject.org/category/gorillas/>If students become more interested in sensor technology NC State’s ASSIST center research may be a good extension: <http://assist.ncsu.edu>If students become more interested in gorillas the Gorilla rehabilitation and conservation education center may be a good extension- <http://gracegorillas.org>  |
| **Comments**  | If you do not have time for the whole lesson then the heart monitoring plan on day 2 can be used as a stand-alone sensor lesson. Ideally student presentations would be presented to someone in a relevant field (zookeeper, animal science major at a local college, veterinarian, medical doctor) in order to provide students with real-world feedback.  |
| **Author Information** | My name is Stephanie Bender and I am an 8th Grade science teacher at Centennial Campus Magnet Middle School in Raleigh, NC in the Wake County School System. I have been a classroom teacher since 2014 but prior to entering the classroom I was an animal science and conservation educator at Disney’s Animal Kingdom in Orlando, FL. If you have any questions about the lesson or I can help you implement it in any way please contact me at sbender@wcpss.net. This lesson was created as a part of a Research Experience for Teachers at NC State’s ASSIST Center alongside Dr. Jess Jur and Dr. Elena Veety. The ASSIST center is a research center at NC State University that focuses on creating wearable sensor technology that is self-powered. The ASSIST Center is currently researching and developing state-of-the-art low power sensor technology as well as energy harvesting technology that will maximize power generation capabilities.  |