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| **Introduction**  | Nanotechnology is the next major scientific breakthrough. The development of nanotechnology is extremely promising, but there are unknown risks associated with utilizing nanotechnology. Nanoparticles occur naturally in our environment. Pollen, viruses, and ash are examples of nanoparticles that affect our environment and our health. Scientists have studied the behavior of these nanoparticles in an effort to develop nanotechnology to solve issues associated with our environment and our health. In this project, students will explore innovative science, technology, engineering, math techniques and equipment that demonstrated the multiple uses and importance of nanotechnology. |
| **Real Science Application**  | Humans have positively and negatively impacted the environment for centuries. The human population is increasing rapidly and may soon bump up against environmental limits. Even if population growth were not a serious problem, the increasing use of resources per person is expanding the overall human ecological footprint and putting a strain on the earth’s resources. The time is now to be “solution focused” as opposed to being “problem driven”. Whether it was the implementation of the practice of agriculture, or the boom of the Industrial Revolution, human ingenuity has always sought a way to improve their environment. Currently, STEM is the new focus in education that is being used to develop the next generation of world changers. Nanotechnology is a new approach being used by scientists to develop new technologies, and to address current issues facing our environment. As an educator, you want to be as informed as possible in order to properly inform your students. If students are able to understand the interconnectedness of science (in this case, earth science to biology), then they are able to gain a better grasp of the importance and relevance of their work.  |

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| **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.

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| Content Area | Grade Level | NC Essential Standards | NGSS / Common Core Math |
| Earth Science | 9 | EEn 2.2.1 Explain the consequences of human activities on the lithosphere (such as mining, deforestation, agriculture, overgrazing, urbanization, and land use) past and present. | HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.  |
|  |  | EEn 2.4.2 Evaluate human influences on freshwater availability. | HS‐LS2‐6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.  |
|  |  | EEn.2.8 Evaluate human behaviors in terms of how likely they are to ensure the ability to live sustainably on Earth. | HS‐LS2‐7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.  |

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| **Learning Outcomes**  | Students will develop a concept map to explore human impacts on the environment.Students will review and evaluate various human impacts on the environment.Students will conduct a lab to understand the size and scale of “nano”.Students will create a model for a device that implements nanotechnology that would be used to help the environment.Students will compose an argument (presentation) to explain the importance of their device.  |
| **Time Required and Location**  | Activity #1: (Human Impacts Discussion) 90 minutesActivity #2: (Nanotechnology and the Environment) 90 MinutesActivity #3: (Dirty Water) 90 MinutesActivity #4: (Nano Inventions) 180 Minutes |
| **Materials Needed**  | **Activity #1** (Human Impacts Discussion)* Teacher List
	+ Secure student access to computers or iPads
* Student List
	+ Computers or iPads for concept map (1 per group of 2-4 students)

**Activity #2** (Nanotechnology and the Environment)* White paper
* Dropper
* Food Coloring
* Mouthwash
* 200 mL of Water
* Rinse Cup of Water
* 9 small cups (clear or white) or beakers
* 2 graduated cylinders (10mL)

**Activity #3** (Dirty Water Lab)* Teacher List
* 10–12 lbs. of self-hardening clay
* box of gallon-size Ziploc bags
* 6 in. of thick wire (any metal, as long as it is not enameled—for the teacher only)
* 2 popsicle sticks (for the teacher only)
* 5 lb. bag of sand
* bag of teaspoons (biodegradable spoons made from potatoes work just as well as plastic)
* 25 lb. bag of colored fish tank gravel (NOT blue)
* 50 ml bottle of liquid Miracle Gro fertilizer (model of nanoparticle pollutant)
* 1 gal. distilled water per group
* Paper towels, bottle of surface cleaner, 3 buckets (for cleanup)
* Student List
* a bag of clay
* a metal tray
* a bag of sand
* a bag of rocks
* spray bottle
* distilled water
* fertilizer
* spoon
* plastic micropipette
* water testing kit

**Activity #4** (Nano Inventions)* Teacher List
	+ Secure student access to computers or iPads
* Student List
	+ Computers or iPads for concept map (1 per group of 2-4 students)
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| **Safety**  | Activity #1: There are no lab safety requirements. Please use the district internet safety policy while using electronic devices.Activity #2: Follow lab safety rules that have been established within your class. Goggles should be worn during this lab. Please monitor student use of the mouthwash, as it can be an eye irritant.Activity #3: Gloves should be worn at all times. API freshwater testing kit contains chemicals that irritate the eyes and can be harmful if swallowed. Refer to the MSDS for the chemicals used. If eye exposure occurs, flush with water for 15 minutes and immediately seek medical assistance. Use caution with the clay-cutting tool, as it can cut your hands or fingers. Activity #4: There are no lab safety requirements. Please use the district internet safety policy while using electronic devices. |
| **Student Prior Knowledge**  | These activities are designed to be part of a unit on human impacts on the environment. Students should be familiar with the water cycle, natural resources, ecosystems, and environmental factors such as pollution. |
| **Teacher Preparations**  | Teacher needs to secure access to adequate technology that will be used for the duration of the lesson (5 days). Teacher should prepare lab materials for Activity #2 and Activity #3, prior to the labs being conducted in class. Teacher Prep for Activity #31. Purchase water testing kits.Purchase one kit per lab group. The vials for testing are glass, so if a vial is broken, a graduated cylinder (10 ml) can be substitute for the vial.
2. Make a clay-cutting tool for the teacher only.Wrap one end of the copper wire around the center of one of the popsicle sticks and the other end of the wire around the center of the other popsicle stick. When done, the clay-cutting tool will resemble the capital letter H.
3. Cut the clay into 2-pound cubes (~6 cubic inches).Cut clay using the clay-cutting tool and put each cube inside a Ziploc bag. Seal the bag to prevent the clay from drying out.
4. Familiarize yourself with the water testing kit instructions before class.The recommended test kit is very easy. The instructions are written on each bottle. If you choose another kit, make sure you know what to do beforehand.
5. Label the bins/buckets for easy clean-up.If you are using this just for one class, you may prefer to have students place their trays on a lab cart to expedite the clean-up process. Then, an aide or the teacher can separate the rocks/sand/clay for re-use after class. Or, label one bucket Sand, another Rocks, and the other, commingled items (sand/rocks/fertilizer/water).
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| **Activities**  | **Activity #1**: **Human Impacts on the Environment**Engage: Students will construct a concept map on the effects of human impacts on the environment. The guiding question is: How do humans positively and negatively impact the environment? Within their groups, they are to visit the website [www.popplet.com](http://www.popplet.com) to construct their concept map. (20 minutes) Explore: Students will view “The Lorax” video to examine human impacts on the environment. The cartoon version, which is the most appropriate and time efficient version, can be found on YouTube <http://youtu.be/8V06ZOQuo0k> (30 minutes)Explain: Students will complete the video questions sheet after viewing “The Lorax”. Extend: Students should be able to answer the following questions as a result of their work:Evaluate: As a class, discuss the following questions1. Explain how the environment affects the quality of life for individuals and society.
2. Think about you and your family’s use of the environment. What are the primary and secondary uses of the environment.
3. Discuss the impacts your generation has on the environment, and how those impacts affect future generations.

**Activity #2: Nanotechnology and Our Environment**Engage: Filter Sorter Activity. Using the Ball Sorter Apparatus, you are to conduct a class demonstration. Show the class the 3 different spheres that you have. Ask the students the following questions: What spheres do you see? What color spheres do you see? How would you separate the spheres? Stack the sieves in size order. Make sure that the screens with the larger holes are on top. Slowly pour the spheres into the stacked set of screens. Shake the screens back and forth for at least 15 seconds. Carefully separate the screens. Ask the students to describe what happened.Explore: Students are to view the video “Decoding Nano”, which provides an overview of nanotechnology, and the benefits and risks associated with it. <http://youtu.be/dMZphr05rDY>After viewing, students are to write a TPEQEA summary of the video.Explain: Students are to complete the “One in A Billion” Activity to understand the nanoscale. This lab is designed to teach students the importance of taking accurate measurements. Students will follow instructions on the Student Data Sheet 2A to complete the lab. Evaluation questions following the lab should be discussed as a class.Extend: Students are to complete Student Data Sheet 2B for an extension of the lab.Evaluate: Students are to complete the Lab Discussion Questions.**Activity #3 Dirty Water**Engage: Students are to view the Ted Talk by Michael Pritchard entitled “How to Make Filthy Water Drinkable” <http://www.ted.com/talks/michael_pritchard_invents_a_water_filter>After viewing, they are to complete a TPEQEA summary for the video.Explore: Students are to conduct the Nanoparticles Lab. Students will follow the procedures on Student Data Sheet 3A.Explain: Students are to analyze their data from the lab, and complete Student Data Sheet 3AEvaluate: After lab cleanup, students are to answer the following questions as an exit ticket1. How can small-scale pollution (nanoparticles) travel from a mountain to an ocean?
2. Landfills break down trash into their smallest components over time – many at the nanoscale. If there was a landfill at the top of a mountain without any sort of containment, where could these nanoparticles end up? How? Be sure to use at least 2 terms from the water cycle.
3. What is the best way to test ocean water for possible contamination after a rain?
4. How might the pollution affect the marine ecosystems in those bodies of water?

**Activity #4: Nano Inventions**Engage: Discuss how nanotechnology is involvedExplore: Assign the students (in groups of 3-4) to research new inventions in the areas you listed in the Engage section. Have the students complete the Brainstorming Chart.Explain: Each group will present their research with the class. As each group is presenting, the remaining groups are to take notes for more information on nanotechnology in our everyday lives. Extend: Students are to create their own “Nano Invention” that could be used to improve human impacts on the environment. Each group is complete 3 parts for their project (A brochure, a 3D model, and a presentation.Evaluate: Students are to present their inventions to the class. Upon completion of the presentations, discussion questions for the class.1. Why are there so many new “nano inventions”?
2. How many of these new inventions are similar?
3. Which inventions are most likely to be widely used by the public?
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| **Assessment**  | **Activity #1**Concept Map/PoppletLorax Video Questions**Activity #2**TPEQEA SummaryStudent Data Sheet 2ALab Discussion Questions**Activity #3**TPEQEA SummaryStudent Data Sheet 3ALab Discussion Questions Exit Ticket**Activity #4**Brainstorming ChartNano Invention Project Rubrics |
| **Extension Activities**  | Researchers are currently developing sensors that will be used to monitor and provide information about the health of animals (stress levels, sickness thru blood indicators, etc.) Your group has the following task:Using the engineering design process, construct a prototype for your device. You may use the following 3D websites to construct your model (Tinkercad or Sketch Up). Once you have completed your 3D model, we will take a field trip to NC State University. Here, we will have your 3D model printed, as well as tour facilities where nanotechnology and sensors are being developed. Upon return to class, you are required to write a one page reflection about your experience. |
| **Modifications**  | Modifications can be made as follows:ESL/LD: These students may view “Power of Nanotechnology” video regarding important uses of nanotechnology in everyday applications. Students will write down any interesting fact or idea that they viewed in the video.  |
| **Alternative Assessments**  | The alternate assessment will be for students to construct a concept map of vocabulary words that they learned in the unit. You will provide them with the concept map template, as well as the vocabulary words that should be used.  |
| **References**  | *Jones, M. Gail. Nanoscale Science: Activities for Grades 6-12. Arlington, VA: NSTA, 2007**Aono, Masakazu, and Tomihiro Hashizume. Nanoscale Science:. Tokyo: JJAP, 1993* |
| **Comments**  | The lesson plan is made for a unit in Earth/Environmental Science classes, but it can also be adapted for Biology and AP Environmental Science classes.  |