Nanotechnology for Human Health

INTRODUCTION

Students will research an application of nanotechnology (nano) in the health care or medical field in order to understand how nanotechnology is applied in practice. They are then challenged to create infographics and build 3D models at scale to share their knowledge with audiences beyond the classroom. The lesson emphasizes self-directed and collaborative learning, and motivates students through exposure of their work to real-world audiences.

This project-based lesson incorporates both life sciences/biology outcomes alongside engineering design. Before delving into exploration of scientific application, students must first understand the body systems and their functions as they would operate normally to maintain homeostasis. In Grade 8, Unit B: Cells and Systems, as well as Science 10, Unit C: Cycling of Matter in Living Systems, students will have learned about cells as part of a larger system; this lesson will build on that understanding with greater sophistication regarding how cellular components contribute to homeostasis and how multiple systems interact. Once students have developed models of healthy body systems, they can then come to understand what dysfunction may look like and appreciate technologies being developed to address complex human health concerns.

This lesson in particular emphasizes the intrinsic links between Science, Technology, Engineering, and Math. In order to successfully build the 3D scale model of a nanotechnology application, students must comprehend not just the nanoscale but also how that scale relates to measurements that can be seen with the naked eye. The model will allow other students to more easily see the structure of the nanotechnology being presented, and make explicit connections between structure and function.

Nanotechnology represents an exciting emerging field and is an extremely relevant application of scientific knowledge. Through this project, students are exposed to emerging careers available to them beyond high school, and see how technology is furthering solutions to real-world challenges being faced in the field of medicine today.

In previous science instruction, students should have had experience defining criteria and constraints of a design problem with sufficient precision to ensure a successful solution. In doing so, they would have begun to consider the impact on people and the environment as limiting factors in design solutions. Now, in this high school-level lesson, students take the engineering and technology design outcomes to a more sophisticated level and analyze a major global challenge (in this case, a significant medical problem being faced by humanity, such as cancer) to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. Risk mitigation as it pertains to the application of nanotechnology in medicine is something that students will consider as they compare nano solutions for health concerns to more traditional therapies for these issues.

CURRICULUM CONNECTIONS

Biology 20, Unit D: Human Systems

Focusing Questions:

- How do specialized structures function in the overall biochemical balance of the living system?
- What conditions result if these structures do not function normally?
- How does knowledge of living systems and medical technology support the prevention and treatment of disorders?

General Outcomes: Depending on the student project choice, one or more of the general outcomes in Biology 20 will be addressed. Specific learning outcomes will vary depending on project.

Students will:

1. explain how the human digestive and respiratory systems exchange energy and matter with the environment
2. explain the role of the circulatory and defence systems in maintaining an internal equilibrium
3. explain the role of the excretory system in maintaining an internal equilibrium in humans through the exchange of energy and matter with the environment
4. explain the role of the motor system in the function of other body systems.

Biology 30, Unit A: Nervous and Endocrine Systems

Focusing Questions:

- How does the human body maintain equilibrium between its internal and external environments?
- What physiological processes and control systems are involved in maintaining homeostasis?
- What medical technologies are available to alleviate disorders of the nervous and endocrine systems?

General Outcomes: Depending on the student project choice, one or more of the general outcomes in Biology 30 will be addressed. Specific learning outcomes will vary depending on project.

Students will:

1. explain how the nervous system controls physiological processes
2. explain how the endocrine system contributes to homeostasis.

Science 30, Unit A: Living Systems Respond to Their Environment

Focusing Questions:

- How do the structure and function of the human circulatory system help to maintain human health?
- What are the defense mechanisms of the human body?
- What are the basic principles of Mendelian genetics and how can they be applied to treat genetic diseases?
- What are the risks, benefits and associated ethical issues of current genetic technology?

General Outcomes:

1. analyze how the human circulatory system facilitates interaction between blood cells and the external environment and investigate cardiovascular health
2. analyze the defense mechanisms used by the human body to protect itself from pathogens found in the external environment

Specific learning outcomes from Science 30 will vary depending on student project choice.

Science 24: With modifications (e.g., removal of the 3D scale model with associated calculations), this project can be adapted for Science 24, Unit C: Disease Defence and Human Health for its connections to disease, technology and research advancement for human health.

KEYWORDS

Scale, model, nanotechnology, medicine, health, nanoscale, human body, nanoscience

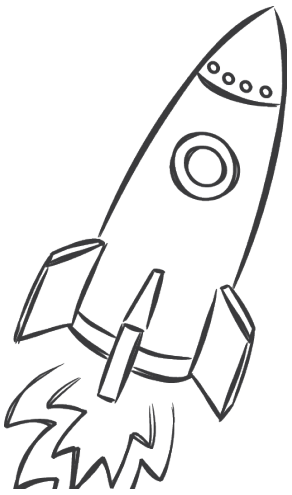
TIME

2 weeks

MATERIALS

- Digital access to **Do You Know What Nano Means?** and **Nano Careers**
- Variety of construction materials for building scale models - students can provide, or use miscellaneous classroom materials - examples include:
    - Scissors
    - Tape, glue
    - Cardboard
    - Construction paper
    - Aluminum foil
    - Popsicle sticks
    - Straws
    - Plasticine
- **Appendix A: Nanotechnology for Human Health Student Workbook**
- **Appendix B: Nanotechnology for Human Health Project Rubric**
- **Appendix C: Supplementary Resources**

HOW TO DIFFERENTIATE AND ENRICH LEARNING



Knowledge is accessed and built by:

- Watching and listening to videos and presentations
- Discussing and interviewing
- Reading text, articles, and research papers
- Viewing and interpreting images, photos and graphs
- Note taking by writing or voice recording (audio workbook)
- Mind-mapping
- Collecting and tracking real-world data

Knowledge is applied/contextualized, practiced, and understood by:

- Sharing personal stories
- Game play with flexibility for reinforcing/repeat
- Choosing personally relevant research topics or projects
- Testing ideas through building, experimenting, and prototyping
- Answering formative (check-in) assessment questions
- Drawing and creating storyboards and diagrams
- Evaluating and incorporating feedback

Knowledge and understanding are demonstrated by:

- Thoughtful reflections and accurate answers in writing or otherwise (journal, test etc)
- Final product uses choice of multi-media (video, website, poster, podcast)
- Creating a product with real-world relevance/applicability
- Creating a product for users/audiences beyond the classroom
- Final product meeting rubric indicators – with student choice for what should be assessed
- Formal oral presentations; participation in campaigns and model displays
- Building model representations for visualizing things that are too small to see
- Collaborating and providing useful/correct feedback to others

Day 1: Introduction to Nanotechnology

To begin the lesson, students first need to be introduced to the concept of "nano." They will likely be familiar with the microscopic scale and units of measurement smaller than the millimeter, but they may not have been exposed to the nanoscale or the application of nano (i.e., understanding the terms nanoscience and nanotechnology). Through two videos, **Do You Know What Nano Means?** and **Nano Careers**, students will first learn the definition of nano and then learn about various emerging fields for the application of nanoscience. The project for this lesson focuses on nanotechnology in health and medicine, so students will begin to focus on more specific medical-related applications of nanoscience as they prepare for project work.

Components for Day 1:

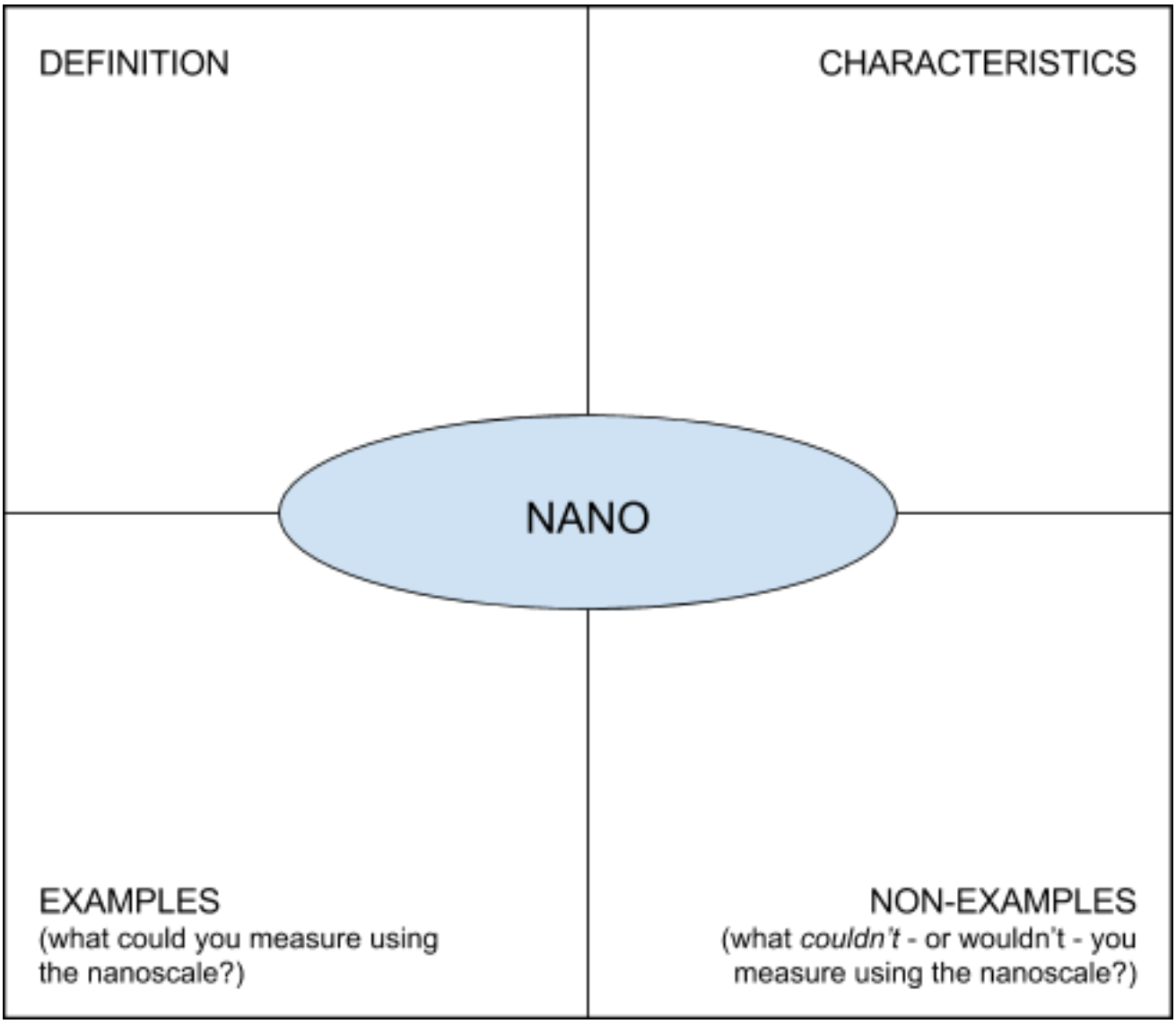
- **Do You Know What Nano Means?** (video)
- **Nano Careers** (video)

Day 1: Outline

1. To introduce students to the idea of "nano" - a scale that is so small it can't be seen with the naked eye, nor even a conventional microscope that students will have used - start the class with one or more hands-on activities. The following activities are suggested:
    - **Activity 1:** How small can students cut a sheet of paper? Begin by cutting it in half, then half again, then half again, and so forth. Ask students: can they get it under a microscope and continue to cut it into even smaller halves? How small can they get? Discuss that the scale of nano will be even smaller than what they are able to create with this sizing activity.
    - **Activity 2:** Can students identify nano? Show students photos such as those found here: **Engineers in the Classroom**. Ask students: Can they identify what the object being pictured is? Can they identify what size it is? The captions of each photo reveal both the size and identity of each photo subject, and show captivating visuals of the nanoscale.
    - **Activity 3:** Practicing the nanoscale. Either as individuals, small groups, or as a class, students can work through the activity "**The Scale of Things,**" which gives students the opportunity to learn and understand more about the nanoscale before jumping into applications.
2. To begin to better define "nano" and understand how it is used in science, watch the video, **Do You Know What Nano Means?**

Day 1: Outline Continued...

3. In small groups or as a class, work to complete the following Frayer model/four-square definition of "nano":



4. Once this definition and exploration of nano is complete, ask students to consider: Why would I want to learn about the nanoscale? How is it relevant to me/us? Discuss these ideas with the class and collect student responses and ideas for future reference. It is encouraged to revisit these questions at the conclusion of this lesson exploration, to see how student ideas may have shifted because of the lesson activities.
5. To introduce the concept of how the nanoscale can be applied in real-life applications, next watch the video **Nano Careers**.
6. Have students respond to the following questions:
    - What are the similarities and differences between "nanoscience" and "nanotechnology"?
    - This lesson's project will focus on nano applications in the medical field. What are some of the examples mentioned in the video - and why were they developed (i.e., what problems were they addressing)?

Students may need to re-watch the relevant components of the video in order to respond to these questions - assess for student understanding and give students ample time to solidify their grasp of these concepts before moving forward. If students need additional support to understand the nanoscale, nanoscience and nanotechnology, **Appendix C: Supplementary Resources** can be used with students either in class or outside of class to further support student learning.

Day 2: Bridging Nanotechnology to Life Sciences

On Day 1, students were introduced to the concept of the nanometer as a unit of measurement, the nanoscale, and nanotechnology as applications for nano. On Day 2, the focus shifts to applying nano to the life sciences. This sets the foundational framework for project work (Days 3-7+) and shows students the connections between the human body's operations to maintain homeostasis, disruption to that balance (i.e., disease), and nanoscience.

Components for Day 2:

- **Visualizing the wonder of a living cell (TED Talk video)**
- Internet access for research (optional)

OUTLINE

1. Begin the class by watching the TED Talk video, Visualizing the wonder of a living cell (running time: 9:45). In particular, have students attend to the following questions while watching:
    - What cellular components are mentioned in the video?
    - What units of measurement would be best for measuring each of these components (in particular, the nanometer)?
    - What are the functions of different cellular components?
    - What is the overall function(s) of the entire cell - how does it serve the human body?

    Students can either write their responses and then share in small groups or a large class discussion can be facilitated to debrief on the video content. The **video transcript** is a good guide for conversation - e.g., kinesin (mentioned at 7:49) takes steps that measure approximately 8 nm each.
2. In Grade 8, Unit B: Cells and Systems, as well as Science 10, Unit C: Cycling of Matter in Living Systems, students would have learned about cells and the systems that comprise the human body. Generate a class-wide mind map to capture this knowledge about the human body; challenge students to list body parts and then categorize them under the following body systems:
    - Cardiovascular/circulatory
    - Digestive/excretory
    - Muscular/skeletal
    - Nervous
    - Urinary/renal
    - Reproductive

- Respiratory

Additional systems that students may need support in exploring, but categorize common body components:

- Endocrine (i.e., hormones)
- Exocrine (e.g., skin, hair, nails, sweat)
- Immune/lymphatic

3. For an optional Math connection, for each body part listed that comprises a bodily system, have students identify the most practical unit of measurement to use (note: online research may be needed). Where is the nanoscale used? How is scale reflected in each component of the full system?
4. To reinforce the concept of balance and how systems interact to maintain the body's homeostasis, students should then begin to explore what disease or malfunction in these bodily systems could look like. Using one of the following methods, encourage students to identify which systems work together in creating (or resolving) illness and/or disease:
    - Online research of a specific bodily system's functions and/or specific disease
    - Small groups assigned to a specific system to describe what role each body part plays in the system - and how the system is affected if one part is removed

    This idea is expanded upon in the project work that follows. Students should be encouraged to start identifying what body system(s) or function(s) most interest them, as it will form the foundation for their future research.

    Optional: Encourage students to focus on a technology that may have personal relevance to them - for example, if a friend or family member suffers or has been afflicted by a particular disease for which there are nanoscale solutions, they can focus their research there.

Days 3-7 (approx.): Project Work & Presentations

For the remainder of the lesson, students apply their understanding of the nanoscale, nanoscience and nanotechnology to an emerging technology in medicine. Currently, nanotechnology is being developed to solve a myriad of health-related problems, from cancer treatment to precision surgery (Note: supporting information and suggested websites are provided in **Appendix A: Nanotechnology for Human Health Project Instructions)**.

Students will work either individually or in small groups to research and present one specific nanotechnology application in the healthcare/medical industry. They will be asked to create three deliverables:

1. 2D models incorporating both words and pictures of both a healthy system and sick system that the technology can potentially treat. Note: multiple models may be required to demonstrate processes and components at various scales.
2. A 3D scale model of the application.
3. An infographic to communicate information about the problem and the application.

This project will call on students to use mathematics and computational thinking in order to create an accurate scale model, and will make the nano size visible through their creation. The infographic is a useful tool for communicating scientific concepts in an engaging way that is easily understood by the general public - something that scientists and engineers are called on to do in practice every day.

Before commencing project work, conduct formative assessment to ensure student understanding of the nanoscale (see Day 1) and review **Appendix B: Nanotechnology for Human Health Project Rubric** so that students understand their assessment for this work. If necessary, use Appendix C: Supplementary Resources for additional support for students who may need further review before moving forward.

Components for Day 2:

- **Appendix A: Nanotechnology for Human Health Project Instructions**
- **Appendix B: Nanotechnology for Human Health Project Rubric**
- **Appendix C: Supplementary Resources**

1. Give students the following challenge, ether as individuals or in groups of 2-3 students:

   Research a nanotechnology application for the healthcare or medical industry.

   Then:

   - Draw a 2D model showing an illness that is the focus of this treatment and also a healthy system for comparison.
   - Build a 3D scale model to make the device or application easy to visualize and understand in the classroom.
   - Present the illness/problem and application to the class in an infographic.

2. **Research:**

   Students can conduct their research online and through interviews, magazines, books and other resources, using reputable sources and referencing them properly (more information on the research phase, along with suggested sources for research, are provided in **Appendix A: Nanotechnology for Human Health Project Instructions**). Have students focus on gathering the following information:

   - What is the name of the technology?
   - What purpose does it serve/what problems/illness is it addressing?
   - How does the system function with the problem/illness?
   - How is a healthy system supposed to function?
   - What structures or devices does this technology use? What do they look like? What is their size?
   - How does this technology work - can you explain its function?
   - What are its advantages compared to more traditional approaches?
   - Who benefits from this technology?
   - What are the risks associated with this technology?
   - What is the cost of implementing this technology?

   Optional: Encourage students to focus on a technology that may have personal relevance to them - for example, if a friend or family member suffers or has been afflicted by a particular disease for which there are nanoscale solutions, they can focus their research there.

3. **Refine:**

   Have students prepare a storyboard/PowerPoint (slide deck) to share their preliminary findings with the class. This initial presentation should include:

   - A brief description of the illness/problem and how biological processes are changed at a nanoscale
   - A brief description and explanation of the nanotechnology application
   - A plan/design or concept of the infographic
   - An illustrated model or plan for the 3D scale model
   - References/sources used

In this phase, classmates and teacher(s) ask questions and provide feedback, like giving feedback on a draft. The feedback will then be evaluated by students and incorporated into the final product. Students should strive to help each other in creating the clearest possible presentations/infographics and 3D representations of their chosen technologies, creating products that are easy to understand and pleasant to view.

Once feedback has been given, students should use this information to improve and refine their storyboard/slides. Then they convert the slides into an infographic and 3D scale model for their chosen nanotechnology application. As an additional option, students can create an assessment tool (such as a game, quiz or survey) that can probe their audience for understanding and ensure learning has taken place after engaging with the student's infographic and 3D scale model.

4. **Models:**

   The two-dimensional (written/drawn) model should be two-part, illustrating both the diseased system that the nanotechnology application is addressing as well as a healthy body system for comparison. Students should use both pictures and words to demonstrate their understanding.

   Using the information on the structure (design) of the technology and how it works, along with size and dimensions, students must then build a physical, three-dimensional model of their technology. This includes putting the scale on their model (e.g., 1cm = 1nm) and accurately representing the technology's structure. The scale and size that students use is their choice, but it must easily be seen and held in the classroom.

   Depending on the nanotechnology application chosen, it is important for students to show (as much as possible) the technology in context. For example, if a particular nanodevice is operating in a blood vessel, students should attempt to model not just the nanodevice but also the surrounding environment of the blood vessel, to give context for the technology and also illustrate relative size.

5. **Infographic Presentation:**

   Students must create an infographic to showcase their research findings and present the nanotechnology to their peers. Use the project rubric to guide presentation creation. Suggested websites for infographic creation (along with sample infographics, for students who are unfamiliar with this format of presentation) are provided in **Appendix A: Nanotechnology for Human Health Project Instructions.**

At the conclusion of project work, students should be given the opportunity to present their models and infographics to their peers. As a final discussion, classes can return to the questions from Day 1: Why would I want to learn about the nanoscale? How is it relevant to me/us? Students can discuss what other applications of the nanoscale hold relevance in their lives moving forward.

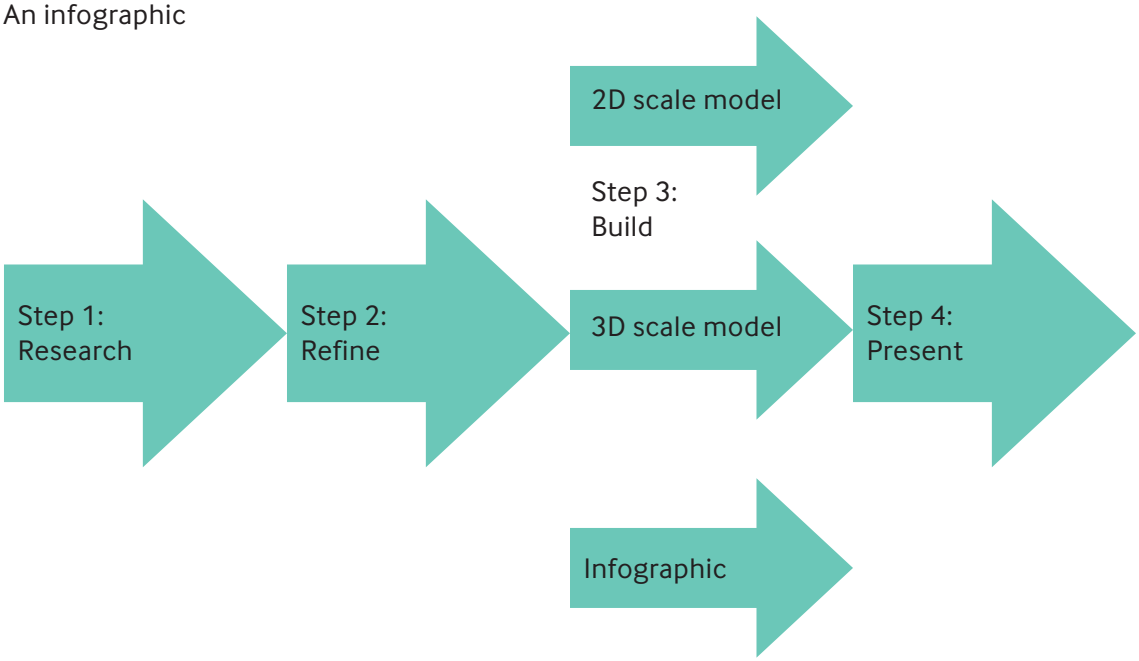
NAME: _____ **CLASS**: _____ **DATE**: _____

How can nanotechnology help us solve medical problems? This research project will answer exactly that!

Your task: Research a nanotechnology application from the medical/health field and present it using both:

A. 2D models showing the biological system both functioning normally and with the problem/illness
B. A 3D scale model, and
C. An infographic

The Plan:



STEP 1: RESEARCH

Your task is to **choose one medical nanotechnology application** that piques your interest to be the focus of your project. Start by browsing through resources (online, videos, articles, etc.) and discuss with peers, teacher(s), parents and community members. Use the suggested websites and other prompts below to help you get started.

Answer the research questions below, along with any additional information you find. Make sure to keep track of your sources for a bibliography.

Research Questions

- What is the name of the technology?
- What purpose does it serve/what problems is it addressing?
- What structures or devices does this technology use? What do they look like? What is their size?
- How does this technology work - can you explain its function?
- What are its advantages compared to more traditional approaches?
- Who benefits from this technology?
- What are the risks associated with this technology?
- What is the cost of implementing this technology?

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Suggested websites for research:

- Cell Biology/Introduction/Cell Size
- Nano in Healthcare
- National Nanotechnology Infrastructure Network
- National Institute for Nanotechnology
- Ingenuity Lab

Suggested articles:

- Nanotech drug delivery shows promise for improved melanoma treatment
- Disguised Nanoparticles Slip Past Body's Immune Defense
- IBS Creates a Wearable Graphene-based Biomedical Device to Monitor and Combat Diabetes
- Nanotechnology Against Malaria Parasites
- A new technique for purifying blood using a nanofiber mesh could prove useful as a cheap, wearable alternative to kidney dialysis
- New Approach May Lead to Inhalable Vaccines for Influenza, Pneumonia
- On-demand vaccines possible with engineered nanoparticles
- Nanotech to Regrow Cartilage and Soothe Aching Knees
- Self-Propelled Micromotors Take Their First Swim in the Body

Examples of nanotechnology applications for healthcare and medicine:

CANCER TREATMENT

- Chemotherapy drugs are delivered directly to nucleus of cancer cells; specialized star-shaped gold nanoparticles loaded with drugs are attracted to a protein present only on the surface of cancer cells; the nanoparticles dissolve and release the drugs only when inside the cancer cell
- Bismuth nanoparticles are used to concentrate the radiation onto the targeted tumors thus making the treatment more effective and reducing side effects
- Barrel-shaped DNA-based nanobots (origami nano-robots made of DNA) take suicide instructions to leukemia cells
- Antibodies specific to breast cancer cells are attached to nanotubes and direct them to the tumor; the nanotubes are hit by laser beams which produces heat and incinerates the tumor

CANCER DIAGNOSIS

- Carbon nanotubes carrying cancer-specific antibodies are used to detect cancer cells in the blood
- Small blood sample is added to nano-sheet that has cancer-specific antibodies attached to it; only cancer cells in the blood will stick to the sheet; cancer cells are then visualized with fluorescent marker

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Examples of nanotechnology applications for healthcare and medicine continued..:

TREATMENT OF VARIOUS DISEASES

- **Stroke treatment**: nanoparticles coated with clot-busting drugs are used to clear away blood clots that obstruct blood vessels in the brain
- **Brain injury treatment:** using gelatin nanoparticles was found to be more effective than traditional methods
- **Diabetes treatment:** sponge-like nanostructures that include capsules with insulin are added to the blood of diabetes patients; a rise in blood glucose triggers the release of insulin
- **Anti-viral and anti-parasite therapies:** nanoparticles that keep viruses and parasites from spreading and multiplying inside one's body
- **De-toxifying therapy:** sponge-like nanostructures are specifically designed to attract and collect toxin molecules from blood

IMPROVEMENTS IN HEALTH CARE

(general methods for PREVENTION, DIAGNOSIS, TREATMENT)

- **Vaccination:** delivery of vaccines inside nanoparticles increases the vaccine lifetime and strengthens the immune response it triggers
- **Oral drug delivery:** nanoparticles that can pass through the intestinal wall and into the bloodstream allow for oral delivery of drugs that otherwise/traditionally would need to be injected
- **Precision surgery:** lens coated with carbon nanotubes improves focus of laser beams thus making surgical interventions less invasive (less damage to surrounding tissue that is healthy)
- **Sensor for detecting inflammation:** a gel containing carbon nanotubes is injected under the skin to detect and monitor markers of inflammatory diseases present in the bloodstream (for example, nitric monoxide)
- **Tissue repair and regeneration**: Various nano-materials and nano-fibers are used for wound dressings, implants, tissue engineering and artificial organ parts.

NAME: _____ **CLASS**: _____ **DATE**: _____

STEP 2: REFINE

Prepare a storyboard/powerpoint (slide deck) to share your findings with the class. This should include:

- A brief description and explanation of the nanotechnology application
- A plan/design or concept of the infographic
- An illustrated model or plan for the 3D scale model
- References/sources used

Use the space below to document the feedback that you receive from your initial presentation.

	Peer Feedback	Teacher Feedback	My Response/Plan (Changes, Fixes)
Positives & things that were liked			
Things that were confusing - questions remaining			
Negatives & things that weren't liked			
Things missing			
Any other feedback			

STEP 3: BUILD (MODELS, INFOGRAPHIC)

2D Models:

Using pictures and words, draw the body system that is being addressed by this nanotechnology application. Two versions are needed - both a healthy system and what is happening in the diseased system. Ensure labels are used to identify the body parts involved and consider using arrows or other labels that illustrate how the diseased system is malfunctioning.

3D Scale Model:

Build a physical, three-dimensional model of your technology. This includes putting the scale on your model (e.g.,

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1cm = 1nm) and accurately representing the technology's structure. The scale and size that you use is your choice, but it must easily be seen and held in the classroom.

Depending on the nanotechnology application chosen, it is important for you to show (as much as possible) the technology in context. For example, if a particular nanodevice is operating in a blood vessel, you should attempt to model not just the nanodevice but also the surrounding environment of the blood vessel, to give context for the technology and also illustrate relative size.

Infographic Presentation:

Create an infographic to showcase your research findings and present the nanotechnology to your peers. Use the project rubric to guide presentation creation. Suggested websites for infographic creation are below. Remember to give the information from your research in a creative, aesthetically pleasing way! Include all your sources (bibliography) on your infographic.

Suggested websites for infographic creation:

- Piktochart
- Canva
- Venngage

STEP 4: PRESENT

Your class will bring together all the infographics and 3D scale models for a nanotechnology exhibit or showcase. You'll need to be able to present to your peers, explain your technology and answer questions. At the end, your project will be assessed using the project rubric.

Appendix B: Nanotechnology for Human Health Project Rubric

How to use this rubric:

- Provide this rubric in advance of starting the project - make sure that students understand evaluation - or, if desired, the indicators can be created collaboratively with students for greater ownership over what they are trying to achieve.
- This rubric can be used both for self-reflection and for teacher evaluation.
- Students can choose which four of the six categories they wish to be evaluated on, for a total of 100%. Teacher comments and feedback is encouraged for all categories, regardless of which scoring categories are selected.

OUTCOMES	Indicators (can be demonstrated in different ways)	Comments and Feedback	Score
Research and self-directed learning	• Makes productive use of resources, including time • Seeks information independently and effectively • Requests and uses assistance in reasonable and adequate ways • Keeps track of ideas and documents information effectively		25%
Plan and Design	• Storyboard (or slide deck) covers all questions • Includes plan for assembling infographic and models Includes proposal for intro and theme to class album and model display • Seeks and documents peers' feedback to improve accuracy, clarity and consistency		25%
Revision, Building & Final Product	• Shows critical thinking in the evaluation and incorporation of feedback • Content, including labeling of models, is sufficient, clear and accurate • Infographic and models follow guidelines and class theme • Provides critical input toward intro and theme to class album and model display		25%
Knowledge & Understanding	• Makes contributions in review sessions indicative of a good grasp of topic • Infographic and models show clear understanding of content • Outlines correctly main differences between traditional and new technology • Answers questions competently and clarifies the technology for new audiences • Creates effective assessment tool to probe for understanding		25%
Collaboration	• Provides useful feedback on peers' plans and designs • Responds to feedback from peers in a constructive and respectful manner • Makes thoughtful and substantial contributions to class album and display • Strives for good alignment of info-graphic and models with class project		25%
Communication and Presentation	• Infographic presents information in a clear and effective way • Models and labeling help in visualizing the technology and how it works • Infographic and modesl are eye-catching and creative		25%

Appendix C: Supplementary Resources

Other Wonderville videos and discussion questions that support exploration of nanoscience and can be used as part of this lesson include::

Note: To access the following resources a free membership on **Wonderville.org** is needed.

Digital Resources	Suggested discussion questions
Entrepreneurship in Nano	• What is the main purpose of Biolithic's device? • What problem (or problems) does this technology address? • What are some of the challenges that Biolithic faces? • What technology shares the same origins at Biolithic's device?
Working with Nanotechnology	• What industries are using nanotechnology? • Why might smaller parts (components) be beneficial? • The video says nanotechnology can be "designing a way for a thing to build itself" - what things might need to be built?

Other titles:

- **A Cup Full of Nano (comic)**
- **A Maze in Nanocrystals (comic)**
- **Dig Into Nanotechnology (comic)**
- **Electron Microscopy (lab activity)**
- **Enter the Nanotube (comic)**
- **How do Plants Use Nanotechnology? (lab activity)**
- **Materials Nanotechnologist (video)**
- **Nanotechnology Connoisseur (blog)**
- **The Color of Gold is Red (comic)**
- **Working with Science: Nils Petersen (video)**