Biomedical Engineering Lesson Plan

ADAPTABLE FOR GRADES 6-8

Can be adapted for two 90-minute plans or four 45-minute plans

NANOPARTICLES

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BEAMS Challenge

NIH National Institute of Biomedical Imaging and Bioengineering

BEAMS Biomedical Engineering Adapted for Middle Schoolers
Technologies to Shape the Future of Health

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Nanoparticles Lesson Plans

1st 45 Minute Class

Lesson Title: Exploring Nanoparticles in Drug Delivery

Grade Level: 6th-8th
Grade Duration: 45
minutes Lesson
Objective:
To introduce students to the concept of nanoparticles and explain their usefulness in drug delivery.

Materials:

Whiteboard and markers
Visual aids (images of nanoparticles, drug molecules, and drug delivery)
Gelatin capsules (for the teacher demonstration)
Small candies or colored sugar (for the teacher demonstration)
Beaker or clear container (for the teacher demonstration)

Lesson Summary:

In this lesson, the objective is to introduce students to the concept of nanoparticles and explain their significance in drug delivery. The lesson begins with an interactive discussion to gauge students' prior knowledge, followed by a clear definition of nanoparticles and their size scale using visual aids. Students learn why nanoparticles are useful in drug delivery, addressing challenges like targeted delivery, and controlled release. Real-life examples are shared to illustrate their applications. The teacher conducts a hands-on demonstration using a gelatin capsule to simulate controlled drug release, helping students' understanding. The lesson concludes with a recap of key points, emphasizing the importance of nanotechnology in healthcare and research.

Learning objectives:

- Students should be able to understand and define what a nanoparticle is.
- Students should be able to understand that they have applications in medicine and biomedical engineering, and identify real-life examples.
- Students should be able to understand and define some of the reasons why nanoparticles are needed to solve health problems.
- Students should be able to understand that nanoparticles can carry drugs/medicine, as shown through the demonstration.

Setup requirements:

- Projector to present presentation.
- Gelatin capsules, Small candies or colored sugar, Beaker or clear container for demonstration

Lesson outline/procedure:

- Introduction (5 minutes):
    - Begin by asking students if they've ever heard of the term "nanoparticle" and if they know what it means. Write their responses on the board.
- Definition of Nanoparticles (10 minutes):
    - Provide a clear definition of nanoparticles: Extremely tiny particles that are 1 to 100 nanometers in size.
    - Use the visual aid to help students understand the scale of nanoparticles compared to common objects.
    - Explain that nanoparticles are used in various fields, including medicine.
    - Show the video. Instruct students that the nanoparticles are essentially small, artificially made particles that can be put into the body to help fight diseases like cancer.
- Why Nanoparticles Are Useful in Drug Delivery (10 minutes):
    - Discuss the challenges of drug delivery, such as getting medicines to the right place in the body and controlling the release of drugs.
    - Explain how nanoparticles can help address these challenges:
    - More options for delivery: Nanoparticles can act as carriers for medicines with the benefit of being able to get to places you usually have difficulty getting to because nanoparticles are tiny.
    - Targeted Delivery: Nanoparticles can be designed to deliver drugs specifically to the affected area, minimizing side effects on other areas.
    - Controlled Release: Nanoparticles can release drugs slowly and steadily, improving treatment effectiveness.
    - Protection: They can protect sensitive drugs from degradation until they reach their target.
- Examples of Nanoparticle Drug Delivery (5 minutes):
    - Share examples of real-life applications, such as nanoparticles used in cancer treatment or for delivering vaccines. An example video is shown in the lesson.
- Teacher Demonstration (10 minutes):
    - Conduct a demonstration using a gelatin capsule and colored sugar or small candies to represent the "drug."
    - Explain that the gelatin capsule is similar to the nanoparticle surrounding the drug.
    - Open the capsule, place some colored sugar inside, and reseal it.
    - Submerge the capsule in a beaker of water to simulate drug release.
    - Discuss how the sugar (drug) slowly dissolves and releases into the water, demonstrating controlled release.

- Discussion and Questions (5 minutes):
    - Ask students if they have any questions about nanoparticles, drug delivery, or the demonstration.
- Conclusion (5 minutes):
    - Summarize the key points: Nanoparticles are tiny particles used in drug delivery to improve targeting, controlled release, and treatment effectiveness.
    - Emphasize the importance of nanotechnology in healthcare and research.
- Homework/Extension (5 minutes, optional):
    - Research a chosen disease of interest, focusing on its symptoms, causes, and current treatments. Are there any news articles or papers showing that nanoparticles are being researched for treating this? Write a 2 paragraph summary answering this.
- Adapting the lesson:
    - For 6th graders, focus on simplicity and engagement, introducing basic concepts and terminology while emphasizing the fun aspect of learning. In the 7th-grade adaptation, infuse slightly more complex concepts earlier and introduce more advanced real-life examples to stimulate critical thinking. For 8th graders, deepen the exploration by discussing more advanced scientific principles and the latest developments in nanomedicine.

Assessment (optional):

What is the size range of nanoparticles?

A) 1 to 100 millimeters
B) 1 to 100 micrometers
C) 1 to 100 nanometers
D) 1 to 100 centimeters

Why are nanoparticles useful in drug delivery?

A) They make drugs taste better.
B) They can carry drugs to the right place in the body.
C) They are larger than most drug molecules.
D) They are easy to see with the naked eye.

Which of the following things in drug delivery can nanoparticles NOT help address?

A) Targeted delivery
B) Controlling drug release

C) Making drugs more affordable
D) Protecting sensitive drugs from degradation

What is one real-life application of nanoparticles in drug delivery mentioned in the lesson?

A) Using nanoparticles to make coffee taste better
B) Using nanoparticles to repair phones
C) Using nanoparticles to thin blood
D) Using nanoparticles to carry drugs

During the teacher's demonstration, what did the gelatin capsule represent in relation to drug delivery?

A) A tiny spaceship
B) A protective coating around a drug (nanoparticle)
C) A large container for drugs
D) A common candy

Evaluation rubric:

Criteria:	**1 (Not Understanding)**	**2 (Somewhat Understanding)**	**3 (Totally Understanding)**
Understanding of Nanoparticles	Student demonstrates limited or inaccurate understanding of what nanoparticles are.	Student shows partial understanding of nanoparticles but may have gaps in their knowledge.	Student displays a clear and accurate understanding of what nanoparticles are, including their size and application in medicine.

Understanding of Nanoparticle Applications in Medicine	Student struggles to understand why nanoparticles are useful in medicine and provides vague or inaccurate reasons.	Student can provide some reasons why nanoparticles are useful in medicine but may lack depth or clarity in their explanations.	Student effectively explains why nanoparticles are useful in medicine, offering clear and insightful reasons for their application, including targeted delivery and controlled release.
Understanding of the Teacher Demonstration	Student has difficulty understanding the teacher's demonstration of controlled drug release using a gelatin capsule and colored sugar or candies.	Student can grasp the concept of the demonstration but may not fully understand its significance in illustrating controlled drug release.	Student successfully understands the teacher's demonstration, the role of the gelatin capsule, and how it relates to controlled drug release, showcasing a solid understanding.
Engagement in Discussion	Student does not actively engage in the discussion or ask questions during the lesson.	Student participates in the discussion but may have limited engagement or asks only basic questions.	Student actively engages in the discussion, asks thoughtful questions, and contributes to the conversation, demonstrating a strong interest in the topic.

Homework/Extension (optional)	Student does not complete the optional homework assignment (if assigned).	Student completes the optional homework assignment but provides minimal or vague responses.	Student completes the optional homework assignment with a high level of detail, clear explanations, and demonstrates a deep understanding of the topics covered.

2nd 45 Minute Class

Grade Level: 6th-8th Grade

Lesson Title: Designing "Nanoparticle-Like" Gelatin Capsules for Drug

Delivery Duration: 45 minutes (one class period)

Lesson Objective:

To engage 6th-8th grade students in a hands-on laboratory experiment where they design and create gelatin capsules for controlled drug delivery under predetermined conditions.

Materials:

Gelatin capsules (empty) (get varying sizes, preferably capsules that can be put into one another)
Food coloring liquid, Small candies or colored sugar (to represent "drugs")
Water
Small containers for mixing
Graduated cylinders or measuring cups
Timer or stopwatch
Beakers or clear containers (for testing)

Lesson Summary:

In this laboratory lesson, students engage in a hands-on experiment where they design and create gelatin capsules for controlled drug delivery under predetermined conditions. The lesson begins with a quick review of drug delivery concepts and introduces the experiment's objective. Students learn about the concept of controlled drug release and are tasked with creating capsules that meet specific time-release criteria (typically capsules dissolve in water in 15 minutes, which can be used to show fast-release, if one layer of capsule is added onto another capsule to simulate slow-release, this would likely mean 30 minutes, the teacher should confirm how long it takes to dissolve the capsule before class begins). In small groups, they fill capsules with food coloring liquid, small candies or colored sugar (to represent "drugs"), and observe the capsules' behavior in warm water.

At the same time, another set of the same capsules containing ‘drugs’, along with a predetermined amount of ‘drugs’ are to be put in bigger capsules in order to simulate coating layering, where the ‘drugs’ can be released by the nanoparticle over a longer period of time through having the inner layer not dissolve until the outer layer is dissolved. This shows how ‘drugs’ can be dissolved gradually as each layer disappears (try to have the amount of ‘drugs’ in this layered capsule be equal to the amount previously used in the non-layered capsule, but the

student or teacher has discretion for how they want to layer it, such as a small amount of drugs being released after the first layer dissolves and a large amount released for the second layer dissolves). Time data will be recorded.

Through group discussions and reflections, students analyze their results, gaining a basic understanding of controlled drug release principles and the importance of experimentation in drug delivery systems.

Learning objectives:

- Students should be able to understand and distinguish fast-release and slow-release drug delivery mechanisms.
- Students should be able to understand that nanoparticles can conduct controlled drug release.
- Students should understand the concept of layering and why it plays a role in drug release.
- Students should be able to record data and note differences between the fast release and slow release capsule.

Setup requirements:

- Projector to present presentation.
- Lab equipment
- Notebooks for data recording.
- Timing equipment

Lesson Outline/Procedure:

- Introduction (5 minutes):
    - Start by reviewing basic concepts related to drug delivery and controlled release from the previous lesson.
    - Introduce some examples of ways scientists can control when the nanoparticle releases drugs.
    - Explain that students will be conducting a hands-on experiment to design and create gelatin capsules for controlled drug delivery.
- Experiment Design (5 minutes):
    - Discuss the concept of controlled drug release in simple terms, emphasizing that they will design capsules to control how fast or slow the "drugs" are released.
    - Present predetermined conditions of slow release and fast release.
    - Clarify that students will create capsules to meet these conditions.
- Laboratory Procedure (30 minutes):
    - Instruct students to gather in their groups and distribute the materials.

    - Provide guidelines for creating the smaller capsules: filling them with food coloring liquid, small candies, or colored sugar. The amount can vary depending on the data points needed.
    - At the same time, instruct students to take some of the smaller capsules and put them inside larger capsules. Also instruct the students that additional ‘drugs’ can also be put into this larger capsule along with the smaller capsule.
    - Explain that this simulates coating layering in a drug delivery system.
    - Students should start the timer or stopwatch as they place the smaller capsules and layered capsules into separate water containers.
    - Encourage them to observe and record the behavior of these capsules when placed in warm water. Instruct them to record the time it takes for the smaller capsules to dissolve, and the layered capsules to dissolve.
    - During the waiting period, time can be taken to teach students data recording habits and strategies, as well as help any students that are struggling.
    - Encourage group discussions about their observations and findings.
- Discussion and conclusion (5 minutes):
    - Gather students together to discuss their observations and findings.
    - Encourage them to share their experiences and explain how their capsules met or deviated from the predetermined conditions.
    - Summarize the key points, emphasizing the importance of controlled drug release in drug delivery.
    - Highlight that designing drug delivery systems involves experimenting with different factors like drug concentration.
- Homework (optional):
    - Assign students the following questions. The questions can be altered slightly depending on the student’s grade level:
        - What is "controlled drug release," and how is it different from drugs that work quickly? Can you give an example of when controlled drug release is useful?
        - If you were a scientist making drug capsules, what things would you think about when making them? How would you decide how fast the drug should be released?
        - During the experiment, you made two kinds of capsules - small ones and layered ones. What did you notice about how they released the "drugs"? Why do you think they were different?
        - Why is it good for scientists to do experiments like the one in class when they make drug capsules? How did this experiment help you understand science better, and what parts of it did you find most interesting or tricky?
- Assessment (optional):
    - Ask the students to respond to the following questions either in the class based discussion or in an open answer quiz to gauge understanding of the experiment:

- Tell me about the two types of capsules you made during the experiment: the small ones and the layered ones. What made them different, and why was that important for understanding controlled drug release?
- How did your capsules do in the experiment when it came to releasing the "drugs" quickly or slowly? What factors do you think affected how quickly or slowly a type of capsule released the drug?

Adapting the lesson:
For 6th graders, a simplified approach is recommended, with explanations that are age-appropriate, relatable, and filled with everyday examples to show the concept of controlled drug release. Visual aids such as diagrams and illustrations should be utilized. To accommodate their shorter attention span, the laboratory procedure should be time-managed effectively and can be shortened if needed.

7th graders are ready for a slightly more detailed explanation, building upon prior knowledge. The use of more difficult scientific terminology can be introduced. Students are encouraged to develop independent thinking and hypotheses about capsule behavior in water, and show scientific reasoning. Collaborative group work is encouraged, with defined roles for each student to promote teamwork and cooperation. Additionally, students should be taught effective data recording techniques.

For 8th graders, a more detailed explanation can be used, introducing more in-depth scientific terminology and exploring the fundamental principles of controlled drug release. Students are challenged to design their own experiments within the given framework, allowing for exploration of variables such as gelatin concentrations. After the experiment, critical analysis is encouraged, fostering a deeper understanding of the factors influencing capsule behavior.
Evaluation rubric:

Criteria:	**1 (Not Understanding)**	**2 (Somewhat Understanding)**	**3 (Totally Understanding)**
Understanding of Controlled Drug Release	Student demonstrates limited or inaccurate understanding of controlled drug release and its significance.	Student shows partial understanding of controlled drug release but may have gaps or inaccuracies in their	Student displays a clear and accurate understanding of controlled drug release, distinguishing between fast-release and

		knowledge.	slow-release mechanisms and recognizing the importance of controlled drug release in healthcare.
Application of Layering Concept	Student struggles to understand the concept of layering and why it plays a role in drug release.	Student can grasp the concept of layering but may have some difficulty explaining its role in drug release.	Student effectively explains the concept of layering and its role in drug release, showcasing a solid understanding of how layers influence drug release.
Laboratory Procedure	Student has difficulty following the laboratory procedure and may require significant assistance or guidance throughout the experiment.	Student can follow the laboratory procedure with some assistance and guidance, but may encounter minor challenges.	Student successfully follows the laboratory procedure, demonstrates an ability to work independently or in a group, and records data accurately.
Data Recording and Analysis	Student struggles with data recording and analysis, providing limited or inaccurate observations and findings.	Student records data and provides some observations and findings, but may need improvement in terms of depth and clarity.	Student records data accurately, provides detailed observations and findings, and effectively analyzes the results, showcasing a strong grasp of data recording and analysis.

Engagement in Discussion	Student does not actively engage in the discussion or contribute meaningful insights during the group discussion.	Student participates in the discussion but may have limited engagement or offers only basic insights.	Student actively engages in the discussion, shares thoughtful insights, and contributes to the group's understanding of the experiment, demonstrating a strong interest in the topic.
Homework (optional)	Student does not complete the optional homework assignment (if assigned).	Student completes the optional homework assignment but provides minimal or vague responses.	Student completes the optional homework assignment with a high level of detail, clear explanations, and demonstrates a deep understanding of the topics covered.

3rd 45 Minute Class

Lesson Title: Real-Life Applications of Nanoparticle Drug

Delivery Duration: 45 minutes (one class period)

Lesson Summary:
Beginning with a recap of a previous controlled-release capsule experiment, students dive into the world of nanoparticles in medicine. For 6th graders, the lesson covers concepts like mRNA vaccines using nanoparticles. 7th-8th graders explore more advanced applications, such as nanoparticles in cancer treatment and disease detection. The lesson may include optional video clips to enhance comprehension, followed by a discussion to address questions and reflections.

Lesson Objective:

To introduce 6th, 7th, and 8th-grade students to current real-life examples of nanoparticle drug delivery products and research, showcasing how nanotechnology is transforming medicine.
Materials:

Visual aids (images and slides)
Access to the internet for video clips (optional)
Legos (optional for demonstration)

Learning objectives:

- Students should understand that nanoparticles can treat diseases through targeted delivery via a ligand-receptor mechanism
- Students should be able to explain why nanoparticles are needed in the case studies presented.
- Students should be able to understand that nanoparticles can be augmented/adjusted to fulfill certain needs in healthcare.
- Students should be able to identify and describe examples of how nanoparticles are applied to solve healthcare problems.

Setup requirements:

- Projector to present presentation.

Lesson Outline/Procedure:

- Introduction (5 minutes):
    - Begin by reminding students of the previous experiment where they designed controlled-release capsules to introduce the concept of drug delivery.
    - Explain that today's lesson will explore real-life examples of how scientists are using nanotechnology to improve drug delivery in medicine.
- Nanoparticles in Medicine (5 minutes):
    - Recap from the first lesson that nanoparticles are being used in medicine to make treatments more effective and reduce side effects.
- Ligands and targeted delivery (5 minutes):
    - Introduce the concept of ligands and targeted medicine, and how nanoparticles can be designed to have certain ligands that ‘bind’ more effectively to certain things that have a certain signal or structure.
    - Legos can be used to demonstrate this if the teacher desires, with some pieces’ fitting into other pieces
- Real-Life Examples (20 minutes)
    - for 6th Graders:
        - Present simplified, age-appropriate examples of nanoparticle drug delivery products:
        - Example provided: Vaccines-Discuss how nanoparticles can improve the effectiveness of vaccines.
    - Real-Life Examples for 7th-8th graders:
        - Present slightly more advanced examples of nanoparticle drug delivery products and disease mechanisms.

        - Example provided: Cancer Treatment-Explain how nanoparticles are used in cancer treatment to target and destroy cancer cells.
- Video Clips (optional, 5 minutes):
    - If possible, show short video clips of real-life examples or research in action to enhance understanding and engagement.
- Discussion (5 minutes):
    - Open the floor for questions and engage students in a brief discussion.
    - Encourage them to share their thoughts and ask questions about the real-life examples presented.
- Conclusion (5 minutes):
    - Summarize the key points, emphasizing the role of nanoparticles in transforming medicine.
    - Highlight the potential for students to contribute to scientific advancements in the future.
- Homework/Extension (5 minutes, optional):
    - Research a current research article or paper showing nanoparticle treatment for a disease. Write a 2 paragraph summary on what the disease is, and why do you think the nanoparticle is needed for the disease? If the student feels it's too difficult, they can be encouraged to hypothesize why it's needed.
- Adapting the lesson:
    - For 6th graders: Simplify the explanations and mechanisms, and offer guided research for the homework, and encourage oral presentations and discussion to the class.
    - For 7th-8th graders: Provide more advanced topic choices, delve deeper into the reasonings and mechanisms behind the case studies, and allow students to generate their research questions, expect written reports with visual aids, and oral presentations.
- Assessment (optional):
    - Assess students' understanding through a short quiz or discussion to review the concepts covered in the lecture. Quizzes and assessments will be designed to align with the content/topics presented in each lesson, ensuring that they accurately reflect the key concepts, skills, and knowledge covered. For example, if the teacher presents 2 case studies on how nanoparticles help in treating breast cancer and COVID, then the quiz can be multiple choice questions on the case study content.
    - Example: Nanoparticles helped treat cancer in this example by:

A. Answer 1
B. Answer 2
C. Answer 3
D. Answer 4

Evaluation rubric:

Criteria:	**1 (Not Understanding)**	**2 (Somewhat Understanding)**	**3 (Totally Understanding)**
Understanding of Nanoparticle Concepts	Student demonstrates limited or inaccurate understanding of the role of nanoparticles in medicine, including their use in targeted drug delivery.	Student shows partial understanding of nanoparticle concepts but may have gaps or inaccuracies in their knowledge.	Student displays a clear and accurate understanding of the role of nanoparticles in medicine, including targeted drug delivery and ligand-receptor mechanisms.
Application of Nanoparticles in Healthcare	Student struggles to explain why nanoparticles are needed in healthcare and provides vague or inaccurate reasons.	Student can provide some reasons why nanoparticles are used in healthcare but may lack depth or clarity in their explanations.	Student effectively explains why nanoparticles are needed in healthcare, offering clear and insightful reasons for their application.

Identification of Real-Life Examples	Student has difficulty identifying and describing examples of how nanoparticles are applied in healthcare problem-solving.	Student can identify some examples of nanoparticle applications but may lack detail or clarity in their descriptions.	Student accurately identifies and describes real-life examples of how nanoparticles are applied to solve healthcare problems, providing a clear and comprehensive understanding.
Engagement in Discussion	Student does not actively engage in the discussion or ask questions during the lesson.	Student participates in the discussion but may have limited engagement or questions.	Student actively engages in the discussion, asking thoughtful questions, and contributing to the conversation, demonstrating a strong interest in the topic.
Homework/ Extension (optional)	Student does not complete the homework/extension assignment (if assigned).	Student completes the homework/extension assignment but provides minimal or vague explanations.	Student completes the homework/extension assignment with a high level of detail, clear explanations, and demonstrates a deep understanding of the topic.

4th 45 Minute Class

Lesson Title: Real-Life Applications of Nanoparticle Drug

Delivery Duration: 45 minutes (one class period)

Lesson Summary:

In this lesson, students research and design hypothetical nanoparticle-based treatments for specific diseases, applying advanced scientific thinking. Students research their chosen diseases and recent scientific advancements, gaining insight into symptoms, causes, and treatments. They then design their own to target and treat their selected diseases, focusing on minimizing side effects. Students present their ideas, foster discussions, and gain peer feedback. The lesson emphasizes the complexity of designing nanoparticles for disease treatment, highlighting the role of research, creativity, and critical thinking. Assessment is based on presentations and the depth of nanoparticle designs, evaluating students' understanding and their ability to apply advanced scientific thinking.

Lesson Title: Designing Nanoparticles for Disease Treatment (6th-8th Grade)

Duration: 45 minutes (one class period)

Lesson Objective:

To engage students in a research-based activity where they explore a specific disease or illness and design a hypothetical nanoparticle-based treatment, applying more advanced scientific thinking.

Materials:

- Access to computers or tablets with internet access
- Research materials (books, articles, websites)
- Drawing materials (paper, markers, colored pencils)

Learning objectives:

- Students should be able to design hypothetical nanoparticle-based treatments for the selected diseases, with a focus on minimizing potential side effects.
- Students should gain the ability to apply scientific thinking and creativity in the design of nanoparticle-based treatments.
- Students should be able to effectively present and communicate their ideas to their peers, fostering discussions and receiving feedback.
- Students should be able to conduct online research on specific diseases.
- Students should be able to understand the role nanoparticles would play in relation to

their chosen disease.

Setup requirements:

- Projector to present presentation.
- Laptops/touchpads for students to conduct research

Lesson Outline/Procedure:

- Introduction (5 minutes):
    - Explain that today, students will take on the role of "nano-scientists" and design their own hypothetical nanoparticles to treat a specific disease.
    - Allow each student to select a disease that interests them or that they would like to learn more about.
- Research (15 minutes):
    - Provide access to computers or tablets and guide students to age-appropriate websites or resources where they can research their chosen disease.
    - Instruct them to gather information about the disease's symptoms, causes, current treatments, and recent scientific advancements.
- Designing and creating Nanoparticles (15 minutes):
    - Ask the students to create a detailed sketch or diagram of their nanoparticle design. Emphasize that their designs should reflect their understanding of the disease and how the nanoparticles work.
    - Encourage students to brainstorm and think critically about nanoparticles that could treat their chosen disease. They should consider factors like targeting the disease site, minimizing side effects, and improving treatment efficacy.
- Presentation (10 minutes):
    - Ask each student to present their chosen disease, explain their nanoparticle design, and articulate why they believe it would be effective in treating the disease.
    - Encourage questions, discussions, and peer feedback.
    - If time is short or the teacher feels not everyone can present, then the teacher can modify this so that groups are chosen to research a disease and present together.
- Homework/Extension (5 minutes, optional):
    - Assign a research paper or a more detailed report where students provide in-depth explanations of their chosen disease, the science behind their nanoparticle design, and the potential impact of their hypothetical treatment. This can be a 3-5 paragraph essay.
- Assessment:
    - Assess students' understanding based on their presentation and report of their nanoparticle designs, focusing on their comprehension of disease concepts and their ability to apply advanced scientific thinking in nanoparticle design.

- Adapting the lesson:
    - For 6th graders: During the research phase, guide students to sources with straightforward language and visuals. When designing nanoparticles, encourage basic ideas like tiny capsules to release medicine slowly. In their presentations, let them explain their designs simply. Assess their participation and how well they understood the basic disease concepts. If it is too difficult to encourage self-guided research, groups can be assigned a certain disease.
    - For 7th graders: In the research phase, guide them to slightly more detailed sources. When designing nanoparticles, encourage them to think of more specific disease-targeting features. In presentations, they should explain their designs with some scientific reasoning. Assess their comprehension and creative thinking.
    - For 8th graders: Guide them to more scientific sources during research. When designing nanoparticles, challenge them to think critically about factors like molecular targeting and release mechanisms. In presentations, encourage detailed scientific explanations. Assess their depth of scientific understanding and their ability to think creatively about advanced treatment methods.

Evaluation rubric:

Criteria:	**1 (Not Understanding)**	**2 (Somewhat Understanding)**	**3 (Totally Understanding)**
Understanding of Disease	Student demonstrates limited or inaccurate understanding of the selected disease's symptoms, causes, and current treatments.	Student shows partial understanding of the disease, with some accurate information but also some gaps or inaccuracies.	Student displays a clear and accurate understanding of the disease, including symptoms, causes, and current treatments.
Nanoparticle Design	Student's nanoparticle design lacks clarity and does not reflect a good understanding of how nanoparticles work or	Student's nanoparticle design is somewhat clear but lacks depth in understanding of how	Student's nanoparticle design is well-defined, reflects a strong understanding of

	how they can be applied to the chosen disease.	nanoparticles work for the chosen disease.	nanoparticle functionality, and offers creative solutions for the chosen disease.
Scientific Thinking	Student's nanoparticle design lacks critical thinking and does not consider factors like targeting the disease site, minimizing side effects, or improving treatment efficacy.	Student's nanoparticle design shows some critical thinking but may be inconsistent in considering factors like targeting the disease site, minimizing side effects, or improving treatment efficacy.	Student's nanoparticle design demonstrates critical thinking and effectively considers factors like targeting the disease site, minimizing side effects, and improving treatment efficacy.
Presentation Skills	Student struggles to communicate their ideas and does not effectively engage peers in discussions or feedback.	Student presents their ideas but may need improvement in engaging peers in discussions or handling questions effectively.	Student confidently presents their ideas, engages peers in discussions, and handles questions effectively, fostering meaningful dialogue.
Research Skills	Student's research appears to be minimal, lacks depth, or includes inaccurate information.	Student's research is adequate but may have some gaps or inaccuracies in the information gathered.	Student's research is comprehensive, accurate, and provides a strong foundation for the nanoparticle design.
Homework/Extension (optional)	Student does not complete the homework/extension assignment (if assigned).	Student completes the homework/extension assignment but lacks depth in explanations.	Student completes the homework/extension assignment with a high level of detail and clear explanations.

List of new vocabulary:

Nanoparticles: Extremely tiny particles that are so small you can't see them without a special microscope. Scientists use them to make medicines work better.

Drug Delivery: Technologies that carry drugs into or throughout the body.

Controlled Release: When medicine is given out slowly and steadily over time.

Biocompatibility: A big word that means something is safe to use in our bodies and won't harm us.

Targeted Delivery: A way to make sure medicine goes right to the place where it's needed, like how magnets seek each other out.

Solubility: A word for how well something dissolves in water. It's like trying to mix sugar into tea to make it sweet.

Pathophysiology: Learning about how our bodies work when we're not feeling well, like when we have a cold.

Therapeutic Efficacy: How good a medicine is at making us feel better when we're sick. It's like a report card for medicine to see if it's working.

Dosage: Amount of drug given.

Vaccine: Something you inject to teach your body to fight certain viruses/bacteria

mRNA (Messenger RNA): Molecule that carries instructions for your body to make proteins. It’s like a guidebook for making proteins.

pH: pH is a way to measure how acidic or basic something is.

Degradation: Degradation is when something slowly breaks down or wears away over time.

Layering: Layering is like stacking different things on top of each other, one at a time.

Ligands: Ligands are like keys that fit into specific locks. They are small molecules that attach to other molecules (receptors) in the body, like puzzle pieces that fit together.

Receptors: Receptors are special structures that can receive signals from other molecules (ligands). They are like the locks that specific keys (ligands) can fit into.

Cancer: Cancer is a disease when abnormal cells start to grow and multiply in an uncontrolled way.

Antibody: Antibodies are special proteins that the immune system makes to help fight off harmful invaders, like germs.

Standards met:

- MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-PS1-4: 4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.