STUDENT INVESTIGATION PACKET

MICHIGAN ENGINEERING
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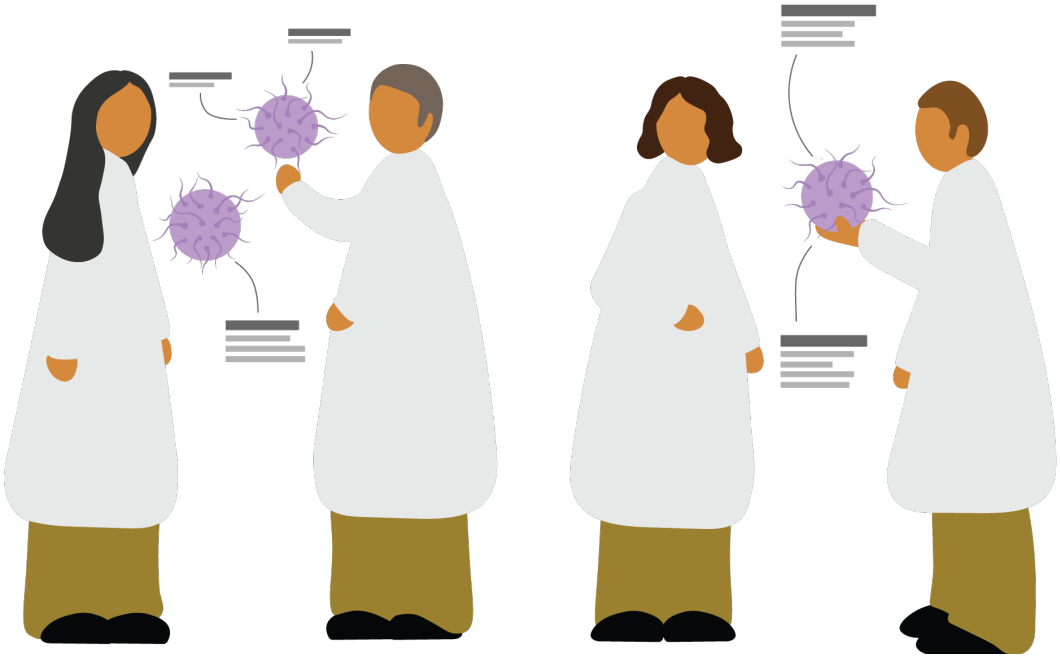


BIG THINGS IN SMALL PACKGES:

BIOFILM, ANTIBIOTIC RESISTANCE, AND NANOTECHNOLOGY

ceder
THE CENTER FOR EDUCATION DESIGN, EVALUATION, & RESEARCH
UNIVERSITY OF MICHIGAN
SCHOOL OF EDUCATION

In this investigation,

you are going to explore the intersections between **medicine, microbiology,** and **chemical engineering.** In particular, you are going to explore the problem of antibiotic resistant biofilms and the potential for nanotechnology solutions.

During the investigation, you will develop a better understanding of the problem, and you will take on the role of a scientist working on an interdisciplinary team to design a medical technology solution to the problem. At the end, you and your team will also prepare and deliver a pitch to get funding for your design (and don't worry… this will all make a lot more sense as you go through the activities).

Let's start the learning off by making some predictions. Think about the title of this investigation, **Big Things in Small Packages: Biofilm, Antibiotic Resistance, and Nanotechnology**, and consider the information and images above.

Turn and Talk with a partner. What do you think you will be learning about? Try to go beyond just repeating the words and break it down a bit more. Look at some of the key words together. What are antibiotics, and what does resistant mean? What do you think biofilms are? What does bio mean? What is a film (not movies or pictures in this case)? What about nanotechnology? What does nano mean? What is technology?

Now **Stop and Jot** to record some of your ideas in the text box below.

I think we will be learning about...

PART 1: Need Title

Let's start this investigation out by building some background knowledge about bacteria and biofilm. Read the text below.

What Are Bacteria?

Bacteria are **microscopic, single-celled organisms** that are neither plants nor animals. They tend to be only a few micrometers in length, and they often live together in communities of millions of cells. A milliliter of fresh water from a pond or stream can hold a million bacterial cells!

Bacteria exist in all environments on earth, even inside of other organisms. Some bacteria that live inside of other organisms can be harmful, but most of them serve some sort of purpose. Bacteria were likely the first organisms on earth and appeared around 4 billion year ago.
(Adapted from https://www.medicalnewstoday.com/articles/157973)

Stop and Jot: What else do you know about bacteria?

So what are biofilms, how do they connect to bacteria, and why are they a problem?

To explore these questions, watch the video linked here:
https://www.youtube.com/watch?v=fpPWbdK9Dno

If the link doesn't work, or you want to just search for it, here is the title:
BIOASTER BIOFILM: major issue on public healthcare 2019 (VOST UK)

As you watch the video, fill out the chart below and then answer the questions after the chart on the next page.

SEE, THINK, WONDER!

What Do You ***See***? Describe what you saw or observed related to what biofilms are and why they can be harmful.	What Do You ***Think***? What do you think is going on with biofilm infections? Why might they be a major problem?	What Do You ***Wonder***? What does it make you wonder? What questions do you have about biofilm now?

Answer the following questions:

1. What is a biofilm?

2. Why are scientists worried about biofilm and the infections they cause?

3. What did you learn from this video that surprised you the most?

Part 2: Your Challenge

Now that you have developed some background knowledge about the threat of biofilm infections, you are going to join a team and work together to learn about how scientists from different specializations can collaborate to help solve this problem. You will work with your team to take on a simulated design challenge that is based on real and ongoing research into this problem.

- Here is the situation: You and your team work at a university that has a major hospital and you have been pulled together to help solve a serious problem. Several patients in the hospital have recently received medical implants (pacemakers for their hearts, hip joint replacements, etc.) that are supposed to save or improve their lives. However, these patients developed infections and almost died because of biofilm infections on the implanted devices. Your challenge is to figure out how this happened and to better understand how biofilms work so that you can design an effective new solution to this problem.

- You and your team will develop a design proposal that will focus on one possible approach to solving the problem of biofilms: the development of new antibiotic treatments that use nanoparticles to attack biofilm or prevent it from growing on surfaces. But how do biofilms form and grow, and how can they be controlled? And what are nanoparticles? How are they made? How are they structured and how do they function? What are their different properties and which properties matter? How do they interact with biofilm?

To answer these questions, you will have to develop your knowledge in two particular areas:

- **Biomedical science and microbiology**
- **Materials science and nanotechnology**

With your teammates, you will read informational articles and watch videos to learn about each of these areas. For each area, you will complete a task to demonstrate what you have learned.

Then, you will develop your proposal for a design to help solve the problem of biofilm infections using nanoparticles.

You will pitch your proposal to a (fictional) group of foundation representatives who want to provide money to your university to research this approach. This audience only has general knowledge of these topics, so you will have to explain your proposed solution effectively and convince them it is a project worthy of their support. Good luck! Let the learning begin.

Building your Biomedical and Microbiology Knowledge

As a team, you need to answer the questions below. To gather the information you need, read the article below and look through some of the videos. Decide how you want to approach using these resources. You don't have to use all of them but you should at least preview them all, and you will need to use several of them. You can also search for answers to the questions and find your own resources. Make sure they are reliable if you do! **Answer all of the questions on this sheet using your own words… no copying and pasting!**

Determine how your team will divide up work responsibilities and make sure everyone has a role and is included in the research process. For example, you might decide that each team member will explore one resource and then work as a group to answer the questions. You will have to make a public presentation about your ideas, so make sure that everyone in your group has a basic understanding of each question.

As directed by your teacher, answer each question here, on a separate sheet of paper, a Google Doc, or in an interactive notebook, then work on the final product for this part of the lesson as a team. Sketching, drawing diagrams, or creating graphic organizers can be very helpful, and you can use them to present your answer to some questions.

1. What are bacteria?

2. Describe two ways bacteria are helpful for our world.

3. List the two different types of bacteria and describe the major difference between them.

4. What are biofilms?

5. Name two places where biofilm can grow.

6. Draw a diagram in the box below (or somewhere else if you want more space) to illustrate how biofilms are structured. Your diagram should show the different components and how they are organized. Please label and explain your diagram. Please include the following components: bacteria; small molecules or proteins; extracellular matrix (ECM); extracellular polymeric substance (EPS); a surface material where biofilm is forming; and small organisms other than bacteria that can exist in a biofilm (e.g fungi, protists).

Legend:

Bacteria ECM EPS Proteins

7. Describe how biofilms are formed and how they grow.

8. What is quorum sensing and how does it help bacteria communicate?

9. Describe one way biofilm can be harmful to humans.

10. What are antibiotics?

11. How do biofilms function to make bacteria more resistant to antibiotics? In other words, how do biofilms protect the bacteria inside them from medicines meant to kill them?

12. Why are infections caused by biofilm such a big problem? Why does it matter that biofilm can resist antibiotics?

13. Throughout this reading we have learned a lot about the unique features of biofilm. These features are what make the biofilm special and help them survive. However, these same features can also lead to serious problems for human health. Below is a table that lists several features of biofilm. Please complete the table by answering why each feature is good for the biofilm, but can also help create conditions that are bad for humans.

Biofilm Feature	Why it's good for bacteria	Why it's bad for humans (or how it can help bacteria do harm)
Extra Polymeric Substance		
Extracellular Matrix		
Quorum Sensing		
Vertical Gene Transfer		

Final Product: You will develop a model that illustrates how biofilms are structured, how they function (what they do), and how they resist antibiotics. This can be a physical 3D model made out of different materials (be creative!); it can be an illustrated and labeled diagram; it can be a computer animation; or it can be a presentation using a tool like Prezi.

Biomedical and Microbiology Resources…
An overview of Bacteria, Biofilm, and Antibiotic Resistance

- **What are bacteria?** Bacteria are microscopic (really, really small), **single-celled organisms**. They are everywhere (including on and inside of us)! Some bacteria play important roles for food, health, and the environment. Some bacteria help us digest our food or make our immune systems stronger. Other bacteria help cycle nutrients, such as carbon and nitrogen through the carbon cycle and nitrogen fixation. Some bacteria even help in creating foods like yogurt through a process called fermentation!

  - On the other hand, some bacteria can be harmful and make us sick, like the Streptococcus bacteria shown on the left that causes strep throat.
  - To stay healthy, we humans need to protect our helpful bacteria and find ways to fight off the harmful bacteria, especially when the harmful bacteria cause an infection in our bodies.

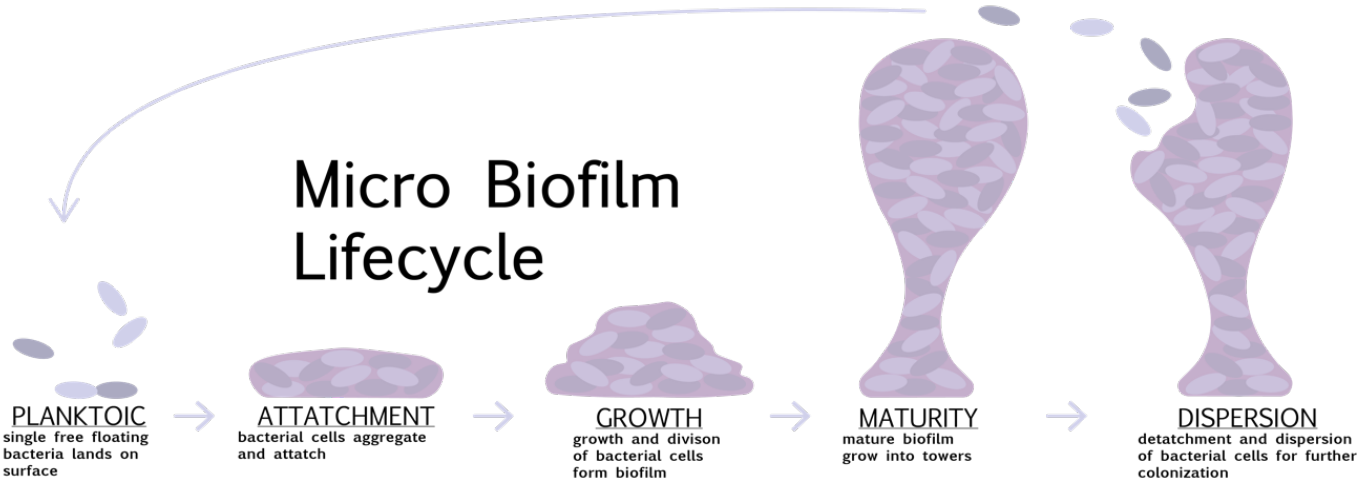
- Bacteria can be categorized into two groups based on their cell wall characteristics. These two groups are called **gram positive bacteria** and **gram negative bacteria.** Gram positive bacteria have a thick layer of a substance in their cell wall called peptidoglycan. In contrast, gram negative bacteria cell walls are covered by a layer of hydrophobic (doesn't mix with water) lipopolysaccharides and have a very thin layer of peptidoglycan. Gram positive bacteria do not have an outer layer of lipopolysaccharides.

- Bacteria can be free-roaming, or **planktonic**. For example, some planktonic bacteria may be drifting freely in a pond, or even in a person's bloodstream. Bacteria can also adhere (or stick) to a surface and become part of a microscopic community called biofilm.

- **What are biofilms?** Biofilms are colonies or connected groups of microorganisms, often bacteria (but they can include fungi and other really small organisms). Biofilms grow on different surfaces like a sort of slime. One of the most well-known biofilms is plaquethat stuff that grows on your teeth! Biofilms grow all over the place on wet surfaces, from rocks in streams to your teeth to the surfaces of medical devices implanted in human bodies. It's actually really difficult to find or develop a surface that cannot be colonized by bacteria.

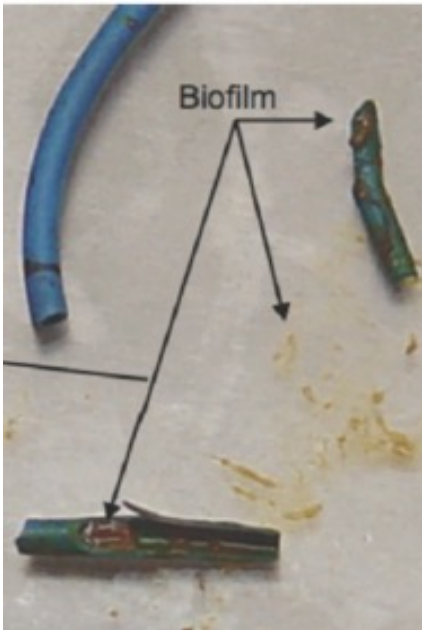
- **How do biofilms form?** Biofilm develops when a planktonic bacteria attaches to a surface, and divides to form a microcolony. The bacteria produce something called an **extracellular polymeric substance (EPS)**, which acts like a cellular glue that bacteria use to stick to things.

As more and more cells attach, they begin producing a matrix, or network, of proteins, sugars , and other cells. This **extracellular matrix (ECM)** binds cells together, protects them, and helps them get the nutrients they need to survive. The biofilm then starts to grow into tiny towers of micro-organisms that eventually **disperse**, or send out, additional bacteria



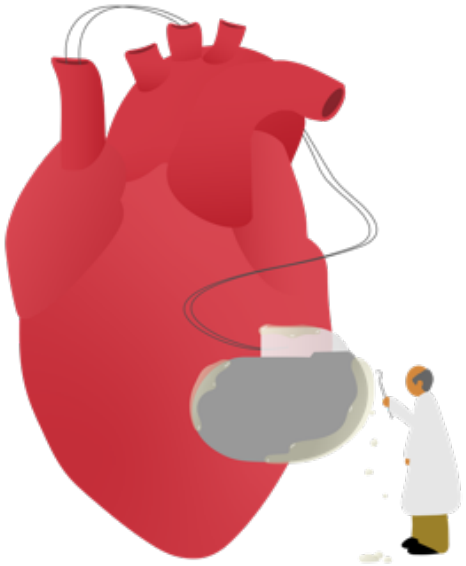
- Biofilms exist as little networked communities. All biofilms have a similar structure of bacteria and possibly other microorganisms, an extracellular matrix, proteins, the EPS glue, and other small molecules. However, each biofilm is unique. Biofilm can be made of one or a few different types of bacteria. They can also have fungi or other microorganisms. In the picture to the right, you can see an image of an actual biofilm. The blue and orange objects are different kinds of bacteria.

- **How do bacteria in biofilms interact?** Bacteria living in biofilm communicate through a process called quorum sensing. **Quorum sensing** is the process in which bacterial cells in a biofilm share information about their community and their environment in order to respond to changing conditions. In quorum sensing, bacterials cells produce signaling molecules called **autoinducers,** and these molecules are detected by other bacteria. As the quantity of bacteria in a biofilm increases, so does the quantity of autoinducer molecules. The bacteria sense this growth and respond collectively to conditions in order to survive and keep growing. Bacteria can alter their **gene expression**, for example, in response to changes in the autoinducers. This means they might, for example , change the instructions in their DNA to make new proteins to help protect the biofilm from antibiotics. Quorum sensing can also signal bacteria in biofilm to grow and colonize their host at a faster rate, which can result in a worse infection in a human body.



- Although biofilms often play a helpful role in the body, they can also do harm and make you very sick. For example, one place where biofilms grow are on medical devices, like the heart stent seen in the picture below on the left. A heart stent is a common medical device for many patients who suffer from coronary heart disease (heart attacks), a very common disease in America. Heart stents, and other life-saving medical devices, can be implanted inside your body to treat serious conditions. Harmful biofilm can grow on medical devices, like heart stents, and can make you very sick. The picture to the right shows a closeup of the stent and inside the stent. That gooey substance inside the stent is a biofilm.

- Bacteria on the biofilm on heart stents and other medical devices can leave the device and move to other parts of the body, and can even then attach to living tissue. Bacteria can reproduce and multiply so fast that they damage tissues where they are and disrupt their normal functions. Bacteria can also kill cells in the body. For example, some bacteria can produce an enzyme that dissolves the materials that helps hold cells together in your body. and they can also produce toxins that block or hurt normal cell functions. They can also cause a large immune response in the body that can actually be damaging.



Antibiotics and Antibiotic Resistance

- **How can we fight harmful biofilms?** Usually, our immune systems are pretty good at controlling harmful bacteria. In fact, we all have bacteria in our bodies that can cause infections, but our immune system (the body's defense mechanism) keeps them in check. Sometimes we get overwhelmed though and our body can't fight off the bacteria, so we need some help. That is where antibiotics can be helpful. One thing to note is that antibiotics don't work on viruses like the common cold.

- **So what are antibiotics?** There are many different medicines out there that work to kill bacteria and some fungi, and they are generally called antibiotics. Antibiotic means "against life." Antibiotics kill bacteria by destroying the cell wall or cell membrane, keeping the bacteria from reproducing, or prohibiting bacteria from making proteins important for bacterial growth and reproduction. You may have taken antibiotics for an ear or throat infection

- **Why can't we take antibiotics to get rid of *harmful* biofilm?** Antibiotics work pretty well to kill some bacteria and biofilm. In many cases though, the antibiotics only kill a portion of the biofilm or don't kill the biofilm at all. This is because biofilms are effective at blocking the antibiotic treatment, or becoming resistant to antibiotics.

- **So, let's take A LOT of antibiotics to get rid of biofilm and all bad bacteria!** This is not a great idea. Using too many antibiotics is actually a bad thing and can lead to antibiotic resistance. Resistance occurs when a microorganism survives, and sometimes even thrives, in the presence of something that should kill or harm it. So antibiotic resistance is just what it sounds like! It means that bacteria, especially bacteria in biofilm, develop a resistance to antibiotics. This means that the antibiotics meant to kill or control them won't work. This is a major health issue in the world right now… we are losing the ability to fight certain illnesses caused by bacteria and biofilm.

- One way biofilms can be resistant to antibiotics is through the extracellular matrix, or ECM. Sometimes, the extracellular matrix provides a protective shell to keep antibiotics from reaching most of the bacteria in the biofilm. Another way bacteria can become resistant to antibiotics is through a process called vertical gene transfer. Vertical gene transfer occurs when a parent bacterial acquires a mutation in its DNA that makes it resistant to the antibiotic. This parent cell passes down, or transfers, that resistance gene to its offspring. The offspring have that same resistance gene and are also resistant to the antibiotic.

- Gram negative bacteria can be harder to kill because of their layer of lipopolysaccharide on the outer cell wall. These bacteria can change their properties, such as hydrophobic characteristics, of that layer to make it less likely to be killed by antibiotics. These are the kinds of changes that get coordinated through quorum sensing.

- Antibiotic resistance is a part of a larger problem in modern medicine. Part of this problem is because we have been using too many antibiotics. Every time we use antibiotics, even if we kill off most of the bacteria, some of the bacteria survive because they might have small differences that help them withstand the antibiotics. These bacteria then reproduce, and the new bacteria have that same resistance. Biofilms provide another layer of protection and make it harder for antibiotics to get to all of the bacteria. Bacteria that antibiotics might normally kill can survive and grow with the protection offered by biofilm.

Links to video resources and other articles:

Great video on quorum sensing
- https://www.youtube.com/watch?v=TVfmUfr8VPA

Additional articles:
- https://kids.frontiersin.org/article/10.3389/frym.2016.00014
- https://kids.frontiersin.org/article/10.3389/frym.2020.00062
- https://www.sciencedaily.com/releases/2018/10/181005111431.htm
- https://science.howstuffworks.com/life/cellular-microscopic/biofilm4.htm

Videos on biofilm:
- https://www.youtube.com/watch?v=9vKzb-JWJfU
- https://www.youtube.com/watch?v=pHLP5CZMnL4
- https://www.youtube.com/watch?v=Aa8WE2LOOcQ
- https://www.youtube.com/watch?v=1XNM4bLgt_U

Part 3: Chemical Engineering, Materials Science, and

Now that you have developed a deeper understanding of the problem of biofilm and biofilm infections, we'll turn our attention to possible solutions. **Chemical engineers**, particularly those involved in what is called **materials science**, are working with microbiologists and doctors to find solutions to biofilm infections using something called **nanotechnology.**

In the text box below, jot down your best guesses as to what these terms mean. Feel free to discuss and compare your ideas with your teammates.

Chemical Engineering: Material Science: Nanotechnology:

Interactive PowerPoint:

To help you understand these ideas better, your teacher will take you through an interactive PowerPoint. Preview the questions below before viewing the PowerPoint, then use the notes and information in the slides to answer the questions.

When you see this explosion icon  it means you'll find an answer on that slide.

1. What is materials science? What do materials scientists do?

2. What is meant by properties of materials? What are some important properties of materials that scientists study and work with?

3. Materials have different properties, such as melting or freezing points, etc. Below is a table from the slide presentation. Complete the table by filling in the missing property or meaning.

Property	**What it Means**
	How much it changes without changing its chemical characteristics; melting point/boiling point; hardness;
Chemical Properties	
	How well they conduct electricity
	How well they conduct heat, how they behave at different temperatures
Optical Properties	
	How they respond to magnetic fields
Mechanical Properties	

Introduction to Nanoparticles

Some chemical engineers in the field of materials science are working to develop new materials that are really, really, really small. These materials are called nanomaterials, and they are made out of things called nanoparticles. Watch this video about Nanoparticles (What is Nano? on the website of National Informal STEM Education Network) and answer the questions below for a quick introduction to the teeny tiny world of nano!

1. What is nanotechnology?

2. What does nano mean?

3. How many nanometers are in 1 meter?

4. What happens to some materials, like gold, at the nano scale?

5. What happens to gold particles when they get to the nano scale?

6. What are some of the ways that scientists are using nanotechnology to solve problems?

7. What are some of the risks of nanoparticles?

Building Your Nanomaterial Knowledge - Guided Reading Questions

1. What is nanotechnology? What are nanomaterials and nanoparticles?

2. Who makes nanoparticles? How are nanoparticles made?

3. What happens to the color of gold (that is visible to the naked eye) when it is a gold nanoparticle?

4. Name some other materials or elements that change their properties when they are nanoparticles?

5. List some properties that nanoparticles exhibit that macrolevel materials do not.

Nanomaterials

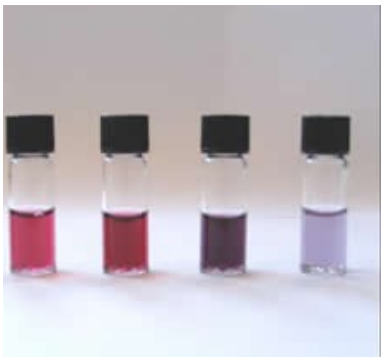
- **So, what are nanotechnology, nanomaterials, and nanoparticles?** Nanotechnology is the general term for the design and production of materials that exist on the nanoscale, with at least one dimension (height, width, length) that is 100 nanometers or less. A nanometer is really, really, really small: 100 millionths of a millimeter. So imagine the millimeter markings on a metric ruler (the smallest markings you will see), and then imagine dividing that into one million sections. That is a nanometer!

- **Nanomaterials** are materials that are made up of individual atoms or molecules, or extremely small structures like crystals. Nanomaterials can be individual particles, tubes, rods, or fibers. **Nanoparticles** are particles that exist on a nanometer scale (i.e., smaller than 100 nanometers in at least one dimension, such as height or length). So nanoparticles are really the building blocks of nanomaterials, and nanotechnology is the term used to describe the design and production of these materials.

- This period . is about 106 nanometers, or 1,000,000 nanometers, and can hold up to 10,000 nanoparticles. A tennis ball is 100 million nanometers, so it is 10 million times bigger than a nanoparticle of 100 nanometers!

- **Nanoparticles are very small. So what?** Nanoparticles are small. *Really small.* Why does it matter that they're so small? It's not just about the size - it's about how size changes the properties of the material. In other words, when a material, such as gold, is reduced in size down to the nanoscale it's properties change. That means the physical, chemical, optical, even conductivity proper-

For example, look at the figure to the right. What do you see? This is a picture of pure gold as we would see it with our eyes at room temperature. Among its other properties, gold has a distinctive color, it's reflective and shiny and pretty hard to the touch. So, does gold always look "golden?" **No!**

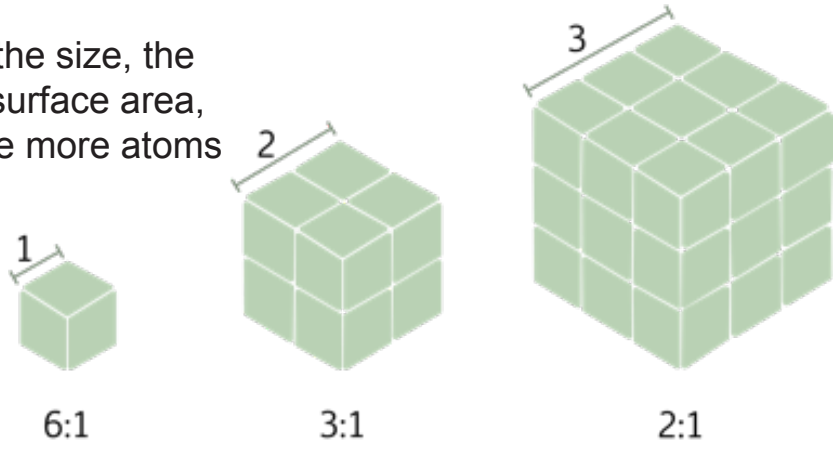


Gold does not always have that "gold" color that we are used to seeing at the macro level, or with the naked eye. Gold nanoparticles actually change their color as they get smaller and smaller. The picture on the left shows us five different tubes that have dissolved gold nanoparticles suspended in a liquid at room temperature. The only difference between these different tubes is the size of the gold nanoparticle. Smaller gold nanoparticles (~20 nm in diameter) have a more red color while larger gold nanoparticles (~100 nm in diameter) have a more blue-ish color.

- **So is it just gold that behaves this way?** Like gold, many other materials, such as silver, aluminum, or even graphene (the stuff that makes up the lead in your pencil), exhibit different properties when they are nano-sized particles. For example, aluminum is a very common element that is used for many items, such as soda cans. Soda cans and other aluminum-based items are mostly unreactive and pretty stable. However, when aluminum becomes reduced to nano-sized particles, it actually explodes when exposed to air!

- Nano-properties are size-dependent. That means, how large or small it is at the nanoscale will determine how the material behaves. At different scales, different forces dominate. One reason for this is the surface area to volume ratio. Larger objects have a given surface area and volume. For example, the unit 3 cube in the picture below has a surface area of 54 units and a volume of 27 cubic units. This makes the surface area to volume ratio equal to 54:27, or 2:1. When that same object becomes smaller, the surface area becomes 6 units, and the volume is 1 cubic unit. The surface area to volume ratio here is 6:1.

So, what does this mean? The smaller the size, the larger the surface area. The larger the surface area, the more reactive it is because there are more atoms at the surface.



Small size = LARGE SURFACE AREA

LARGER SURFACE AREA = **MORE ATOMS TO REACT**

What this means is that there are more atoms at the surface of a nanoparticle that can interact with the environment around it, and this changes the way the materials acts in different environments. For example, physical properties, such as the melting point of a substance can change at the nanoscale. Nanomaterials have a lower melting point than the same material at the macroscale. This happens because, for macroscale items, most of the atoms are on the inside of the object. At the nanoscale, most of the atoms are at the surface. When the atoms are at the surface, more of them will come into contact with heat, making it melt faster.

Part4: Bringing it all together

Next, let's learn about what nanotechnology has to do with biofilm. First let's look at nanomedicine in general.
Watch this video and answer the questions: https://www.nisenet.org/catalog/intro-nanomedicine-video

1. What is nanomedicine?

2. What are some of the problems nanomedicine is trying to solve?

3. What are the building blocks (like Legos) are nanotechnology?

4. Why are nanoparticles useful in medicine?

Bringing it all together: Guided Reading Questions:

1. What are some of the ways that nanoparticles interact with bacteria and biofilm?

2. How can nanoparticles be used to help stop biofilms?

3. Describe three ways that nanoparticles can be used to manage or kill harmful biofilms.

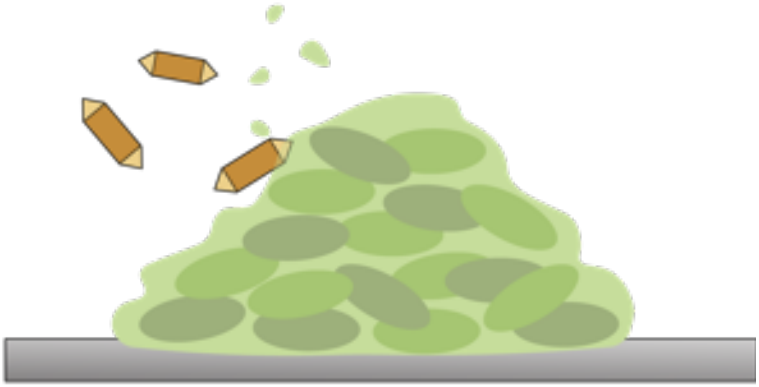
4. What are efflux pumps and how do they function to help protect bacteria from antibiotics?

5. How can nanoparticles be used to stop bacteria from pumping out antibiotics?

Bringing it all together: Nanotechnology and Biofilm:

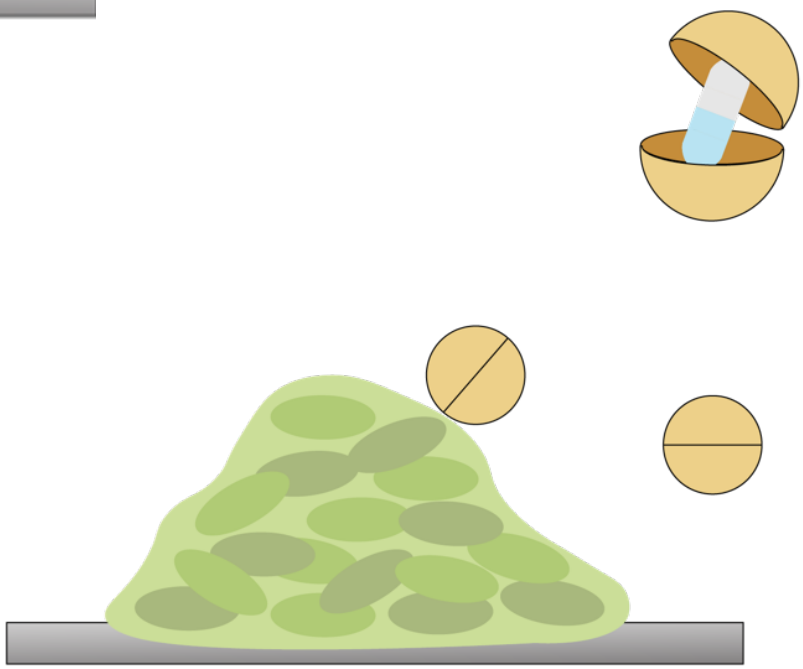
- **What does nanotechnology have to do with biology and things like biofilm?** Nanomaterials can be helpful in fighting antibiotic resistant biofilm because they are so small they can actually slip through the protective defenses of biofilm and deliver medicine to bacteria that are out of reach for normal antibiotics. They are also so small that they can attach to the protective matrix of a biofilm and disrupt it or even break it down. Some nanomaterials can attach directly to bacteria and prevent them from spreading or functioning in a harmful way. Nanomaterials, even though they are so small, have many properties that can be changed to do different jobs, and scientists are still learning how to fight biofilm and bacteria with nanomaterials. This is a new exciting area of research and development that might give us new ways to fight antibiotic resistance!

- In a bit more detail, here are three ways that nanoparticles can be used to control biofilm with basic illustrations (you can create illustrations like these for your final product, but yours will need a lot more detail!).

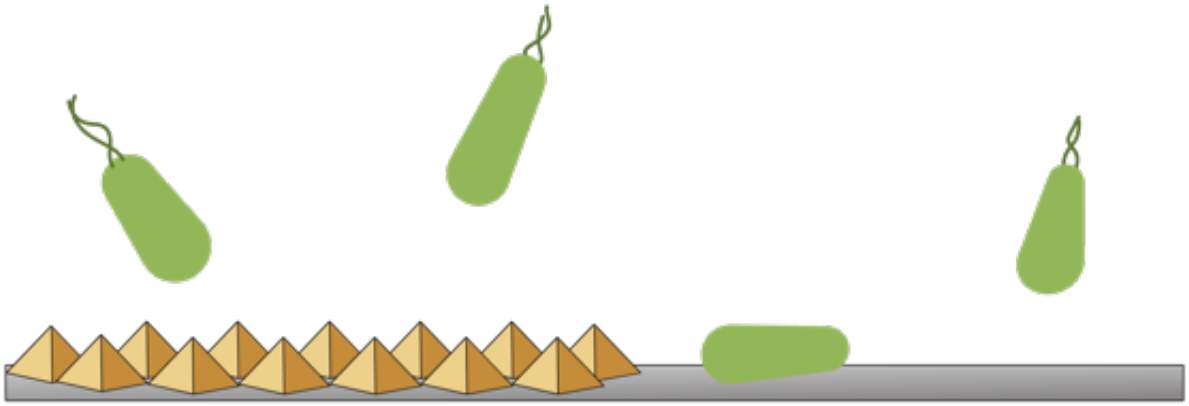


- Nanoparticles can also be engineered to bond with certain sites on the surface of biofilms to either prevent them from releasing bacteria or toxins, or even to begin to break down the structure of the biofilm, in effect dissolving it.

- Nanoparticles can also be used to penetrate the extracellular matrix of biofilm and deliver antibiotics to bacteria inside the biofilm, while traditional antibiotics are blocked from the bacteria by the biofilm structure.

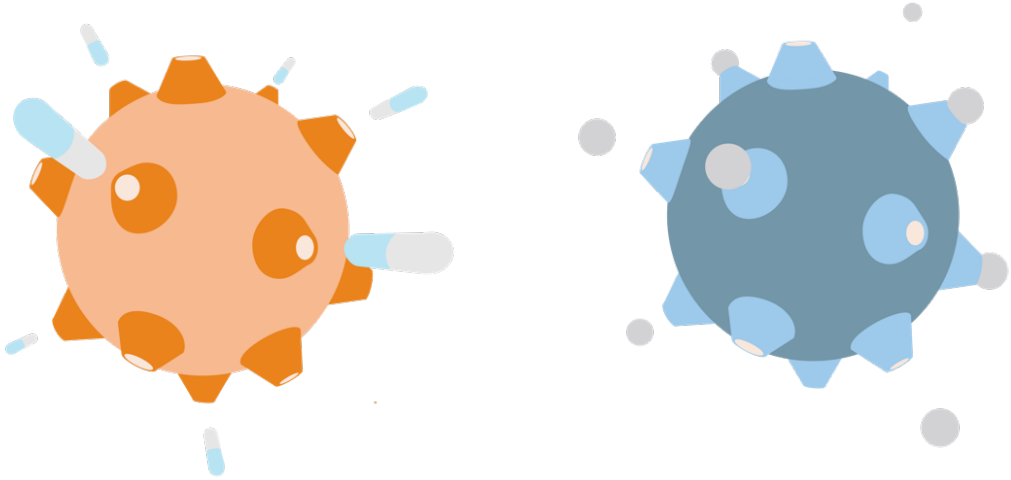


- Nanoparticles with elements like silver or gold or other substances with antimicrobial properties .They form a thin layer that prevents planktonic bacteria (free roaming, individual bacteria) from bonding with the surface and forming a biofilm.



- One team of scientists is working to create gold nanoparticles that are hydrophobic (repelled by water) that connect with the surface of certain bacteria in biofilm and block structures called efflux pumps.

- Bacteria work to maintain their health by using **efflux pumps** to pump out substances that can harm them, like antibiotics that have been absorbed through their cell wall. In other words, when some bacteria absorb potentially harmful antibiotics through their cell wall, they can use their efflux pumps to just pump the antibiotics out before too much damage is done.



- But when these pumps are blocked with nanoparticles, more antibiotic material can concentrate inside the bacteria and kill the cell. The scientists working on this change the size of their nanoparticles as well as their electrical charge to find the most effective structure.

Additional resources on nanotechnology and materials science:

- https://www.uwosh.edu/facstaff/mihalick/Materials/CHAPTER%201.pdf(pages 1-7)
- https://education.mrsec.wisc.edu/nanotechnology/
- https://www.teachengineering.org/content/uoh_/lessons/uoh_matlsci/uoh_matlsci_lesson01_intropresentation_v4_tedl_dwc.pdf
- https://news.engin.umich.edu/2017/08/new-class-of-antibiotics-nanobiotics/
- https://theconversation.com/how-scientists-are-fighting-infection-causing-bio-

Final Design Challenge:

It's a medical device emergency!

A medical device company called **X Device Co** is in desperate need of your help! **X Device Co** makes medical devices that are implanted or inserted inside a person's body as a part of their treatment. Many patients need these devices because they help save lives or make their lives better, BUT they tend to get infected by different types of bacteria, or biofilm. For example, over half of the infections acquired in hospitals are connected to biofilm on implanted medical devices. These infections acquired from biofilm can be quite problematic because they are resistant to many types of antibiotics.v

Medical devices are meant to help patients treat diseases, not to infect them with harmful biofilm! The people at **X Device Co** need your help!

They want you to think of a solution to address the problem of biofilms growing on their devices. You will need to come up with an idea that treats biofilm or prevents harmful biofilm from growing on a medical device. You will propose your idea to the class through a **5-7 minute** pitch to the class.

For your pitch, you will create a poster that clearly indicates the idea or claim you are making. You also need to provide evidence as to why you think that your solution idea will work. You will not have to actually develop a physical product, but you will come up with an idea, sketch out what it looks like, and explain how and why it works. Your explanation must also include the science behind your solution.

You will create a pitch to deliver your idea in front of your classmates. Your pitch/commercial should last between 5-7 minutes.

Your solution can exploit any one of the weaknesses in biofilms, including:

- Breaking down a biofilm's extracellular matrix
- Using nanotechnology/small devices to deliver antibiotics through an extracellular matrix
- Using new nanomaterials for coating medical devices that prevent biofilm from form-

There is a planning sheet that asks you questions, and a presentation guide that will help you think out and deliver your talking points.

Building Your Elevator Pitch

Who is your team?

Write a one-sentence statement that describes your idea.

Now, be a little more detailed and describe your solution in 3 sentences.

What specific feature of biofilm does your solution solve?

How does your solution work to address this problem? Be specific about the concepts involved. (You should have 2-3 bullet points)

How do you think your solution is different from other solutions out there?

Give your solution a name:

You must explain how your nano solution will interact with the structures of biofilm and bacteria, and also how they will impact the function of these structures. You also need to identify at least two specific properties that your engineered nanoparticle will need to have to do this work. Be sure to use at least five of the following key terms. Highlight the ones you are going to use.

- ECM, extracellular matrix
- Cell membrane
- Efflux pump
- dispersion
- quorum sensing
- planktonic bacteria
- adhesion
- prevention
- disruption
- inhibition
- EPS, extracellular polymeric substance

Madlib Elevator Pitch

Use this guide to prepare the talking points of your pitch.

Hi, we are _____, and we are here to tell you about our solution

called_____.

Biofilms are _____
_____,

and they are a HUGE problem for medical devices because:
_____.

The specific feature of biofilm we are addressing is _____
_____,

and this is a problem because:

1.

2.

3.

Our solution _____ addresses the biofilm problem by: _____
_____
_____.

Our solution is unique and different because: _____
_____.

Our product works by_____
_____
_____
_____
_____
_____.

This is better than other solutions because:
_____
_____
_____
_____
_____.