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40_Nanorobots in the human body



BIOS4YOU
AR 2.0

BIO-INSPIRED STEM TOPICS FOR ENGAGING YOUNG GENERATIONS
THANKS TO THE USE OF AUGMENTED REALITY

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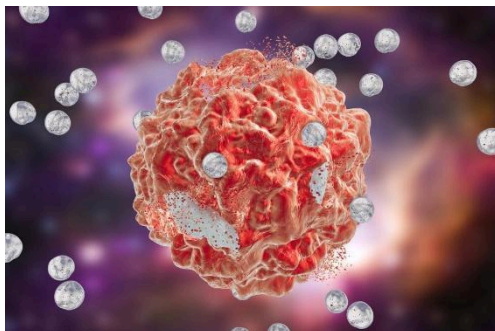




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General topic of the learning path	Nanorobots in the human body
Specific name of the learning unit	<i>How Tiny Particles Deliver Big Solutions</i>
Age of the target users	14-18 years
Requirements for the learner	Basic knowledge of cell biology, chemistry (atoms, molecules, materials), curiosity about modern medicine and technology.
Description of the learning unit	<p>This unit introduces students to the field of nanomedicine, focusing on how nanoparticles transport drugs through the human body. Learners will first explore what nanoparticles are, how they behave at the nanoscale, and why transporting them safely and precisely is one of the greatest challenges in modern medicine. They will then execute interactive activities in an AR laboratory, simulating the journey of nanoparticles through the bloodstream to deliver drugs to targeted cells. Finally, they will enhance their understanding by reflecting on real-world applications, ethical questions, and future challenges of nanomedicine.</p> <p>The goal is to make an abstract and complex field accessible and engaging, showing how science at the smallest scale can solve some of the biggest challenges in healthcare.</p>
Subject: Parties involved	<ul style="list-style-type: none"> • Subjects: Biology, Chemistry, Health Science, ICT/Digital Literacy, Ethics. • Parties involved: Students, teachers, possible guest experts (nanotechnology researchers, healthcare professionals).
Keywords	Nanoparticles, Nanotechnology, Nanomedicine, Drug Transport, Targeted Therapy, Blood–Brain Barrier, Regenerative Medicine, AR Learning.





<p>Key qualifications, skills and knowledge that can be acquired</p>	<ul style="list-style-type: none"> • Definition and properties of nanoparticles. Principles of nanomedicine transport in the body. • Real-world applications (vaccines, cancer therapy, neurological treatment). • Ethical considerations
<p>Resources and didactic aids used</p>	<p>NIH – Nanomedicine: The Future of Medicine Is Small.</p> <p>British Society for Nanomedicine – What is Nanomedicine?</p> <p>TWI Global – What Are Nanoparticles?</p>
<p>Assessment criteria and evaluation</p>	<p>Assessment combines knowledge, skills, creativity, and reflection. Evaluation is both formative (ongoing feedback during AR activities and discussions) and summative (final presentations, group reports, and performance in AR-based assessments).</p>

Introduction

Every second, our bloodstream carries oxygen, nutrients and drugs to every corner of the body. But not all drugs reach the right destination. Chemotherapy drugs, for example, often circulate throughout the body, attacking both healthy and cancerous cells. This causes painful side effects and limits the effectiveness of treatment.

Now imagine if drugs could travel like guided missiles: tiny vehicles programmed to deliver drugs only where they are needed. This is the promise of nanomedicine, a field that applies nanotechnology (which





operates on a scale of billionths of a metre) to healthcare. Nanoparticles can be designed to move through the body, evade natural defences, and deliver treatments directly to diseased cells.

In this learning unit, students will embark on a journey into the invisible world of nanomedicine delivery. First, they will explore the fundamentals of science and medicine at the nanoscale, then carry out interactive missions in an augmented reality (AR) laboratory where they will guide nanoparticles through the human body, and finally, enhance their understanding by reflecting on the possibilities, challenges, and ethics of this revolutionary technology.

Nanomedicine uses structures so small that a thousand of them lined up would be thinner than a human hair. At this scale, materials behave in unusual ways. For medicine, this represents a sea change. Nanoparticles can be designed to carry drugs like tiny capsules, targeting diseased cells with much greater precision than traditional methods.

The importance of this technology lies in its potential to transform the way we treat disease:

In **cancer therapy**, nanoparticles can recognise cancer cells and deliver chemotherapy directly to them, sparing healthy tissue.

In **neurology**, some nanoparticles can cross the blood-brain barrier, a natural barrier that normally blocks most drugs, opening up new avenues for the treatment of brain diseases.

In **infectious diseases**, nanomedicine is already being used in the administration of mRNA vaccines against COVID-19, where lipid nanoparticles protect and safely transport fragile genetic material into cells. By solving the problem of drug delivery, nanomedicine not only promises more effective treatments, but also a reduction in suffering by minimising harmful side effects.

What are nanoparticles?





A nanoparticle is an extremely small particle, measuring between 1 and 100 nanometres. To give you an idea, a nanometre is one billionth of a metre. If you were to cut a single human hair into 100,000 pieces, one of those fragments would be roughly the size of a nanoparticle (TWI Global, 2023).

At this microscopic scale, materials often behave very differently from their larger, bulkier forms. For example, gold, which normally appears shiny and yellow, can appear red or purple when reduced to nanoparticles due to the way it interacts with light. Nanoparticles also have a very high surface-to-volume ratio, making them much more reactive and useful for chemical, biological, and technological applications (PNNL, 2023)

In medicine, nanoparticles are particularly important. They act as microscopic transport vehicles for drugs. Scientists can design them to:

- travel safely through the bloodstream,
- avoid destruction by the immune system,
- attach specifically to diseased cells (such as cancer cells), and
- release drugs in a controlled manner only at the site of the disease.

This ability to deliver treatments with such precision is why nanoparticles are fundamental to nanomedicine. For example, lipid nanoparticles have been essential for transporting the fragile mRNA used in COVID-19 vaccines. Similarly, researchers are testing nanoparticles that can cross the blood-brain barrier, opening new doors for the treatment of neurological diseases ([NIH, 2022](#)).

Explore:

The first step in our journey is to understand the basics.

Students are introduced to the concept that most cells in the body are specialised: skin cells protect, muscle cells contract, and nerve cells transmit signals. Stem cells, on the other hand, are initially generalists.





They are like blank building blocks that can reproduce or transform into specialised cells when needed.

There are three main types of stem cells. Embryonic stem cells are pluripotent, meaning they can become any type of cell in the human body. Adult stem cells, such as those found in bone marrow, are more limited but still essential for replacing and repairing damaged tissue. Then there are induced pluripotent stem cells (iPSCs), a revolutionary discovery by Shinya Yamanaka and Kazutoshi Takahashi in 2006, in which normal adult cells are “reprogrammed” to act like embryonic cells (Takahashi & Yamanaka, 2006).

Students also explore how these cells are already being used in medicine. Bone marrow transplants save patients with blood cancers such as leukaemia. Corneal stem cells are restoring sight in people with damaged eyes (NIH, 2022). And researchers at the Mayo Clinic are studying how stem cells might repair damaged heart tissue (Mayo Clinic, 2023).

At this stage, students gain the essential knowledge: stem cells are nature's repair system, and humanity is beginning to learn how to use them.



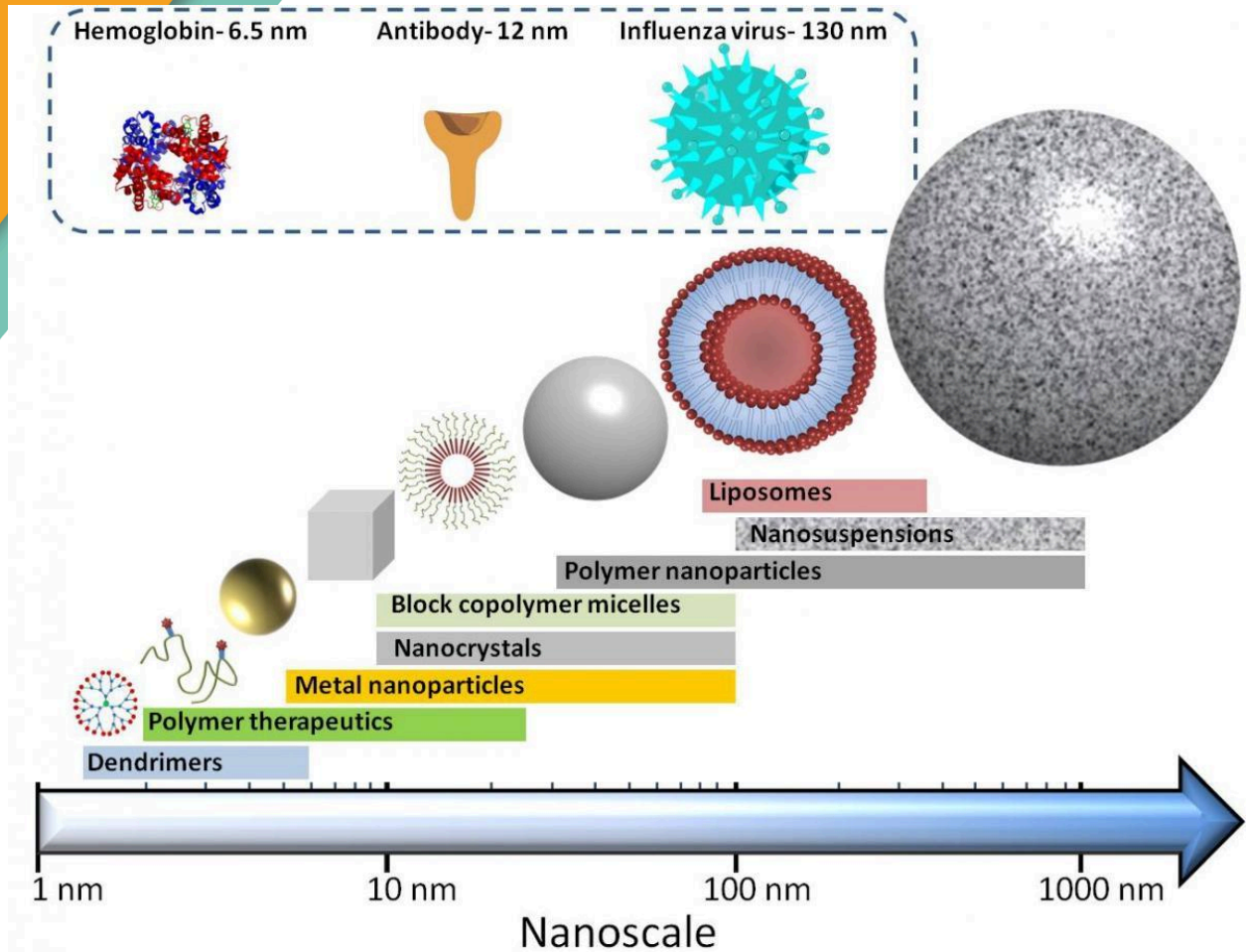


Figure 1 - Source: British Society for Nanomedicine

Execute:

Once the groundwork has been laid, students move on to the execution phase, where they experiment with how nanomedicine transport actually works.

In an AR laboratory, they are virtually shrunk to the size of a nanoparticle and placed in a simulated bloodstream. Their mission: to deliver a life-saving drug to the site of a tumour. Along the way, they must avoid immune cells that are trying to destroy them, navigate through blood vessels, and find a way to overcome cell membranes and release their cargo.





The AR system acts as a guide, offering detailed instructions and visual explanations of each stage of the journey. Students see how different designs, such as coating nanoparticles with “stealth” molecules to hide from the immune system, affect their success.

These interactive exercises are inspired by bio-inspiration in nature. Just as viruses have evolved to enter cells efficiently, nanomedicine engineers mimic these strategies for good. Students are encouraged to reflect: how does nature transport molecules, and what can we learn from it?

Outside of augmented reality, simple classroom activities reinforce the lesson. For example, beads and gel can be used to model nanoparticles moving through barriers, helping students connect abstract ideas with tangible experiences.

Feedback is built into the process. Augmented reality applications show immediately whether the drug has reached its target. Students record their reflections in digital lab journals, and group discussions allow them to share strategies and compare results.

Enhance:

The final phase goes beyond practice to reflection and imagination. Here, augmented reality becomes a tool not only for simulation, but also for critical thinking.

Students explore scenarios involving nanotechnology. Some examples to stimulate learning are:

Is it possible to design nanoparticles that release drugs only when they encounter the acidic environment of a tumour?

- How could nanomedicine solve the problem of drug delivery across the blood-brain barrier?
- What ethical issues arise if we are able to design particles that circulate for months or years within the body?

AR tools make these abstract problems visible, turning them into interactive puzzles. Students manipulate nanoparticles, adjust their properties, and immediately see the consequences.





Gamification deepens engagement: Through these activities, students not only **understand how nanomedicine transport works**, but also reflect on its impact, limitations and future possibilities.

- points and badges reward successfully completed missions.
- Leaderboards encourage collaboration and friendly competition.
- Missions unlock progressively more complex challenges, from treating one organ to delivering drugs to multiple systems.

Group tasks require students to work together to design nanoparticles for different diseases.

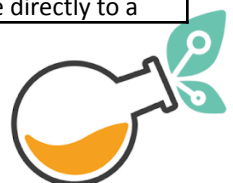
Conclusion:

By the end of this unit, students have traveled inside the bloodstream, experienced the challenges of delivering drugs at the nanoscale, and reflected on why transport is the central question in nanomedicine.

They have explored the science behind nanoparticles, executed hands-on missions that mirror real medical challenges, and enhanced their learning with AR and gamification that made invisible processes visible and engaging.

Most importantly, they have connected science to society, understanding how nanomedicine could shape the future of healthcare by offering more precise, effective, and humane treatments.

Phase	Description
Explore	<p>- Research and Discovery:</p> <p>In this first phase, students are introduced to the world of nanoparticles and their different behaviour at the nanoscale. They discover that a nanoparticle measures between 1 and 100 nanometres, a size so small that a hair is 100,000 nanometres thick.</p> <p>Students learn that in medicine, nanoparticles act as microscopic couriers. They are designed to move through the bloodstream, evade the immune system and deliver treatments only where they are needed, for example directly to a</p>





	<p>cancer cell. They also explore real-world examples: lipid nanoparticles in COVID-19 vaccines, liposomes used in chemotherapy, and gold nanoparticles being tested to destroy tumours with heat.</p> <p>- Content Development: Content is presented through a mix of short videos, diagrams, and simple analogies. For example, the bloodstream is compared to a busy highway, with nanoparticles acting like tiny delivery trucks carrying fragile packages. Students explore the barriers these trucks face: immune cells act like police, the blood–brain barrier is like a checkpoint, and diseased cells are the delivery addresses. This ensures learners gain the core concepts:</p> <ul style="list-style-type: none"> • What nanoparticles are. • Why transporting them effectively is the central challenge of nanomedicine. • How they are already changing medicine. <p>- Needs Analysis: Students at this level often struggle with abstract scales like the nanometer. They need visual aids and interactive demonstrations to build intuition. They also need a clear understanding of <i>why</i> drug transport matters, so that the science feels connected to real human health problems. This prepares them for deeper, hands-on engagement in the next phase.</p>
<p>Exe cut e</p>	<p>- Curriculum Implementation: Students step into a virtual AR laboratory, where they are “shrunk” to the nanoscale and placed inside a bloodstream. Their mission is to transport medicine safely to a target site, overcoming barriers along the way.</p> <p>- Interactive Exercises: : Navigare le nanoparticelle attraverso i vasi sanguigni evitando le cellule immunitarie che cercano di eliminarle.</p> <p>- Feedback Collection: Feedback comes in three layers:</p> <ol style="list-style-type: none"> 1. AR system: Immediate responses on whether the mission succeeded or failed. 2. Teacher observation: Monitoring teamwork, strategy, and problem-solving approaches. 3. Student reflection: Recording outcomes in a digital lab journal, comparing strategies in peer discussion.
<p>En ha nc e</p>	<p>- AR Integration: AR becomes not just a simulation but a problem-solving environment. Students manipulate nanoparticle design: should they coat it with a “stealth layer” to avoid immune cells? Should it release drugs only under certain pH conditions, like those in a tumor? AR allows learners to experiment and immediately see results that would be impossible to observe in a real classroom.</p> <p>- Interactive Learning: Students reflect on the applications and implications. This encourages critical thinking and connects science to society.</p> <p>Gamified Content: Points and Badges: Awarded for each successful mission. Leaderboards: Display group performance and foster friendly competition. Quests and Levels: Students progress from simple delivery tasks to complex, multi-organ challenges. Rewards for Exploration: Extra recognition for innovative strategies or linking examples from current research. Collaborative Gamified Tasks: Teams design and test nanoparticles for different diseases, requiring negotiation and cooperation.</p> <p>AR-Based Assessments: Final evaluation combines AR performance, lab journals, group presentations, and ethical debates.</p>





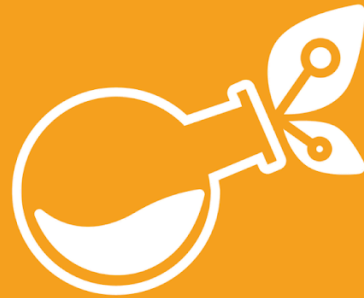
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