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Nanotechnology in Medicine: From Molecules to Targeted Therapy

BIOS4YOU
AR 2.0

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

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Introduction

This document describes the Augmented Reality (AR) exercise titled Nanotechnology in Medicine: From Molecules to Targeted Therapy, designed for students aged 17–19 within the European project BioS4You 2.0 (Work Package 3: AR Exercises).

The aim of this exercise is to help students understand how nanoparticles enable targeted drug delivery and precision medicine, connecting physics (nanoscale phenomena, size-dependent properties), chemistry (material science, molecular interactions, surface functionalization), biology (cellular recognition, receptor-ligand binding), and medicine (cancer treatment, drug delivery systems).

This document follows the standard BioS4You AR Exercise template and is organized into the following sections:

General Information: title, authors, target group, duration, keywords, and topics Pedagogical Specifications: learning objectives, methodology, integration with curriculum Technical Specifications: hardware, software, AR experience design

The exercise has been developed using the 3E approach (Explore – Execute – Enhance), encouraging students to explore nanotechnology mechanisms step-by-step through interactive AR scenes showing nanoscale dimensions, nanoparticle types, drug delivery mechanisms, targeted cancer therapy, and medical applications.

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	General Information
Name of the exercise:	**Nanotechnology in Medicine: From Molecules to Targeted Therapy** From nanoscale design to precision treatment: understanding targeted drug delivery and cancer therapy The title reflects both the scientific principles and practical applications of nanotechnology in medicine. "Nanotechnology in Medicine: From Molecules to Targeted Therapy" emphasizes the dual focus on fundamental nanoscale science and clinical implementation, while the subtitle "From nanoscale design to precision treatment" highlights the journey from molecular engineering and nanoparticle design (gold nanospheres, carbon nanotubes, liposomes) to practical healthcare applications through targeted drug delivery, receptor-ligand recognition, and selective cancer cell treatment. .
Description of the exercises:	Nanotechnology in Medicine: From Molecules to Targeted Therapy is designed for students aged 17–19 to explore the fundamental principles of nanoscale drug delivery and medical applications through Augmented Reality. The main objective is to help students understand how nanoparticles enable targeted therapy through size-dependent properties and how different nanoparticle types (gold nanospheres, carbon nanotubes, liposomes) are used in precision medicine. Students will: • Understand nanoscale dimensions and size comparison with cells and tissues • Visualize different nanoparticle types and their specific medical functions • Explore drug delivery mechanisms and controlled release systems • Learn about targeted cancer therapy through receptor-ligand recognition The AR experience uses Delightex Studio – Spaces (Marker) with 6 sequential scenes and 6 integrated quizzes.
Participants:	The exercise is suitable for both individual students and small groups of 3–5 members. Working in groups is recommended to stimulate discussion about nanoscale phenomena, compare observations of drug delivery mechanisms and receptor-ligand

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	binding processes, and develop collaborative problem-solving skills when analyzing nanoparticle medical applications and targeted therapy strategies.
Participants' age range:	Students should have basic understanding of physics, chemistry, and biology, in particular the concepts of scale and dimensions, molecular structure, chemical bonds, cellular organization, and biomolecular interactions. Prior knowledge of cell biology basics (cell membranes, surface receptors, endocytosis) and organic chemistry (lipids, molecular recognition) is recommended but not mandatory.
STEM subject and specific topic:	STEM Subject: Physics, Chemistry, Biology, Medicine, Engineering Specific Topic: Nanoscale phenomena, drug delivery systems, nanoparticle types (gold nanospheres, carbon nanotubes, liposomes), receptor-ligand binding, targeted cancer therapy, precision medicine applications Main challenge of the topic: Students often struggle to visualize nanoscale dimensions and understand how particles 1000 times smaller than cells can navigate biological systems, why different nanoparticle shapes serve different medical functions, and how receptor-ligand recognition enables selective targeting of cancer cells while protecting healthy tissues. AR visualization helps bridge these abstract nanoscale concepts with tangible medical applications.
Gamification process:	The gamification strategy follows BioS4YOU WP2 guidelines, focusing on challenge-based learning and immediate feedback with Delightex Studio. Challenge-based learning: Students follow the journey from nanoscale design to targeted therapy applications. Each scene presents a quiz that must be answered correctly to proceed to the next stage, creating a progressive learning pathway. Immediate feedback: Delightex provides instant visual feedback when students answer quiz questions. Correct answers unlock the NEXT button and advance the storyline, while incorrect answers prompt students to reconsider the nanoscale and biological principles involved. Achievement unlocking: Scene 6 requires completing all three medical application quizzes to receive the final congratulations message, providing a sense of accomplishment and mastery.

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Written or graphic description of Augmented info:	The AR experience is developed in Delightex Studio – Spaces (Marker) and includes: Scene 1: Title and introduction Title "Nanotechnology in Medicine: From Molecules to Targeted Therapy" with START button Scene 2: Scale and introduction Comparative diagram showing human hair, red blood cells, nanoparticles, and drug molecules demonstrating nanoscale dimensions Scene 3: Types of nanoparticles Three nanoparticle types displayed: gold nanospheres (imaging), carbon nanotubes (drug carriers), liposomes (drug encapsulation) Quiz: Which type encapsulates drugs inside lipid membrane Scene 4: Drug delivery mechanism Step-by-step sequence showing empty dendrimer, drug loading, endocytosis and triggered release, target tissue delivery Quiz: Main advantage of nanoparticle drug delivery Scene 5: Targeted cancer therapy Comparison of healthy tissue (nanoparticles pass by) vs tumor site (receptor-ligand binding and drug release) Quiz: How targeted nanoparticles recognize cancer cells Scene 6: Medical applications Three quizzes on: • Gold nanoparticles for medical imaging • Why nanoparticle delivery reduces side effects • Functionalized nanoparticles in cancer treatment Final congratulations message after completing all quizzes.
External (or extra) tools required	• Devices: Smartphones or tablets with Delightex app installed (iOS or Android) • AR markers: Required; Delightex Studio – Spaces (Marker) uses marker-based AR. Students scan the provided marker to launch the AR experience • Printed worksheets: Optional for note-taking during AR exploration • Internet connection: Required for initial app download and AR content loading
Links (video, images, text online and so on).	**QUIZ** The quizzes are integrated natively in Delightex Studio (scenes 3-6) and do not require external links. Students answer directly within the AR experience with automatic feedback.

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Pedagogical specifications

Here we will collect information on how to use the exercise in the learning session and the results and benefits of using it, from a pedagogical perspective.

How can this augmented information be used to address a STEAM topic in a more interesting way for students?

The AR exercise transforms abstract nanoscale concepts into visual, interactive experiences that students can explore in real time. By visualizing nanometer-scale dimensions and particle-cell interactions, witnessing drug encapsulation and controlled release mechanisms, observing receptor-ligand binding and selective targeting of cancer cells, and making direct connections to real nanomedicine applications, students bridge the gap between theoretical nanoscience and clinical applications. The immersive nature of AR allows learners to manipulate and observe invisible nanoscale processes, making nanotechnology tangible and engaging while demonstrating the interdisciplinary connections between physics, chemistry, biology, and medicine.

Which pedagogical objectives are addressed through this scenario?

The exercise addresses multiple pedagogical objectives across different learning domains. Students develop understanding of nanoscale dimensions, size-dependent properties, and the fundamental differences between nanoparticle types (gold nanospheres, carbon nanotubes, liposomes). They learn to describe drug delivery mechanisms, controlled release systems, and identify nanoparticle medical applications with their specific clinical uses. Through AR visualization, students connect nanoscale molecular design to macroscopic therapeutic outcomes, analyze cause-effect relationships in targeted drug delivery and receptor-ligand binding, and evaluate appropriate nanoparticle choices for different medical procedures. At the competence level, the exercise develops scientific reasoning about nano-bio interactions and critical thinking about nanomedicine safety and efficacy in healthcare settings.

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Which results are expected to be reached with its use?

Students are expected to explain why nanoscale dimensions enable unique biological interactions, describe the role of different nanoparticle structures (gold nanospheres for imaging, carbon nanotubes for transport, liposomes for encapsulation), understand how receptor-ligand recognition produces selective targeting, and match different nanoparticle types to appropriate medical applications based on size, shape, and surface functionalization properties. Assessment of these learning outcomes includes successful completion of all six quizzes during the AR experience, demonstrated ability to compare nanoscale dimensions across biological structures, correct explanation of the targeted drug delivery process and receptor-mediated endocytosis, and appropriate selection of nanoparticle types for specific clinical scenarios.

Which benefits are expected to be reached with its use?

The exercise provides enhanced visualization of nanoscale phenomena that cannot be directly observed, increasing student engagement through interactive AR technology while delivering immediate feedback that supports self-paced learning. Gamification elements maintain motivation throughout the experience. From an interdisciplinary perspective, the exercise integrates physics (nanoscale phenomena, size-dependent properties), chemistry (molecular interactions, surface functionalization), biology (cellular recognition, receptor-ligand binding), and medicine (applications), providing real-world context that demonstrates STEM relevance in healthcare and bridges theoretical nanoscience with clinical practice. Long-term benefits include establishing a foundation for advanced studies in nanomedicine, pharmaceutical sciences, or biomedical engineering, developing understanding of safe nanoparticle use and biocompatibility in various professional contexts, and fostering critical thinking about technology selection based on nanoscale properties and biological interactions.

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Technical specifications

In this part it is necessary to specify whether the exercise was designed to be implemented with AR technology. This part is fundamental for the translation process. Please include text, audio text and all the necessary materials.

AR INFORMATION

Technology	https://edu.delightex.com/AFR-QZE Delightex Studio – Spaces (Marker) The exercise is designed to be implemented entirely with Augmented Reality. It uses marker-based AR, since Delightex Studio – Spaces (Marker) requires students to scan a printed marker to launch the AR experience and view the nanoscale drug delivery scenes on their device screen.
If it's needed a marker, description of the marker	A specific marker is required for Delightex Studio – Spaces (Marker). The marker is a printed image or pattern that students scan with their smartphone or tablet camera to launch the AR experience. The marker can be a custom-designed image related to nanotechnology (such as a nanoparticle symbol or molecular structure diagram) or a standard QR-style pattern provided by Delightex.

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Hardware and software needed:	• Hardware: Smartphones or tablets with camera and internet connection. Gyroscope and accelerometer are required (standard in most modern devices) • Software: Delightex app (free, available on Android and iOS). Teachers need a Delightex educational account to access and share the AR project • Other: Printed marker for each student or group
Type of Augmented data	The AR experience integrates different types of content: • 3D text (title "Nanotechnology in Medicine: From Molecules to Targeted Therapy", scene labels, quiz questions) • Images (nanoscale comparison diagram, nanoparticle types illustration, drug delivery mechanism sequence, targeted cancer therapy diagram) • Interactive buttons (START, NEXT, QUIZ buttons) • Text overlays (explanatory messages about nanoscale dimensions, drug encapsulation, receptor-ligand binding) • Quiz interface (multiple-choice questions with automatic feedback)
Written description of the AR data	When students open the exercise with Delightex app and scan the marker, they begin with Scene 1 displaying the title "Nanotechnology in Medicine: From Molecules to Targeted Therapy" as 3D text. Tapping START leads to Scene 2 showing the nanoscale comparison diagram with human hair, red blood cells, nanoparticles of various sizes, and drug molecules. Students visualize the dramatic size differences demonstrating how nanoparticles are 1000 times smaller than cells, small enough to navigate biological systems. Scene 3 displays the three nanoparticle types: gold nanospheres (multiple golden spheres for imaging), carbon nanotubes (cylindrical structures for drug transport), and liposomes (spherical lipid bilayer vesicles for drug encapsulation). A quiz asks which type encapsulates drugs inside a lipid membrane before enabling NEXT. Scene 4 shows the drug delivery mechanism in four stages: Empty Dendrimer (unloaded structure), Dendrimer Loaded with Drug (active cargo molecules inside), Endocytosis & Triggered Release (cellular uptake with pH trigger), Target Tissue & Receptors (drug

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	release at destination). Students visualize the complete delivery pathway from loading to release. Quiz addresses the main advantage of nanoparticle drug delivery. Scene 5 presents targeted cancer therapy comparing healthy tissue versus tumor site. Students see healthy cells (green) where nanoparticles pass by harmlessly, and tumor cells (red) displaying specific surface receptors that bind to nanoparticle ligands, triggering selective drug release through receptor-ligand recognition. Quiz covers how targeted nanoparticles recognize cancer cells. Scene 6 presents three consecutive quizzes about medical applications: gold nanoparticles for medical imaging and diagnostics, why nanoparticle delivery reduces side effects (targeted delivery affects fewer healthy cells), and functionalized nanoparticles delivering chemotherapy directly to cancer cells. Completing all three reveals congratulations message.
If Image	If the AR data are Images, the formats needed are .jpg and .png (better size < 2Mb). The exercise uses multiple images: • Scene 2: Nanoscale comparison diagram showing human hair, red blood cells, nanoparticles of various sizes, and drug molecules • Scene 3: Nanoparticle types illustration showing gold nanospheres, carbon nanotubes, and liposomes with labels • Scene 4: Drug delivery mechanism diagram showing step-by-step intracellular delivery (empty dendrimer, loaded with drug, endocytosis and triggered release, target tissue and receptors) • Scene 5: Targeted cancer therapy diagram comparing healthy tissue (green cells, nanoparticles pass by) and tumor site (red cell with receptors, ligand binding, drug release)
If Text	Short explanatory messages are displayed as text overlays inside Delightex Studio. Scene 1: Title and subtitle Scene 2: "Nanoparticles are 1000x smaller than cells - small enough to navigate bloodstream and penetrate tissues" Scene 3: "Different nanoparticle shapes serve different medical

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	functions: spheres for imaging, tubes for drug transport, liposomes for protecting medications" Scene 4: "Nanoparticles act as delivery vehicles: they carry drugs through bloodstream, enter target cells, and release medication precisely where needed" Scene 5: "Targeted nanoparticles recognize cancer cell receptors like a lock-and-key mechanism. Healthy cells lack these receptors, so nanoparticles pass by harmlessly. Tumor cells display specific surface receptors that bind to nanoparticle ligands, triggering drug release precisely where needed" Quiz questions: • Which nanoparticle type can encapsulate drugs inside a lipid membrane? • What is the main advantage of nanoparticle drug delivery? • How do targeted nanoparticles recognize cancer cells? • Which medical application uses gold nanoparticles for visualization? • Nanoparticle drug delivery reduces side effects because: • In cancer treatment, functionalized nanoparticles can: Final message: "Congratulations! You've successfully completed the Nanotechnology exploration! You now understand how nanoparticles deliver drugs precisely to target cells while protecting healthy tissues."
If video	-
If audio	-
If 3D model	3D models in Delightex Studio can be used in formats compatible with the platform (.glb, .obj). The exercise primarily uses 3D text elements for titles and labels. Optional enhancement could include importing 3D models of nanoparticles, cell structures, or molecular representations from libraries compatible with Delightex.

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