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Augmented Synapse: Travel Inside the Brain

BIOS4YOU
AR 2.0

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

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General information

This document describes the Augmented Reality (AR) exercise titled Augmented Synapse: Travel Inside the Brain, designed for students aged 14–19 within the framework of the BioS4You project.
The aim of this exercise is to help students understand the biological and physical principles of signal transmission in neurons through a clear and interactive learning experience. Using Assemblr EDU, students will access an AR environment where they navigate through different scenes showing the complete human nervous system and detailed synaptic transmission between two neurons on a real-world surface (such as a desk or classroom table). By interacting with the first neuron, students progress through sequential scenes that demonstrate how electrical signals initiate, how neurotransmitters are released across the synaptic cleft, and how the second neuron responds.
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, interact, and reflect throughout the learning process.
Thanks to AR, students are immersed in an enriched environment where text, 3D objects, and scene transitions appear in the real world. This combination of digital media and physical space helps to visualize invisible processes, strengthen interdisciplinary connections between biology and physics, and support a deeper understanding of how the brain transmits information.

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Name of the exercise:	**Augmented Synapse: Travel Inside the Brain** Electrical and chemical signals at work in the synapse The title reflects both the scientific content and the immersive nature of the exercise. Augmented Synapse emphasizes the use of AR to visualize processes that are normally invisible to the human eye, while Travel Inside the Brain conveys the exploratory and experiential character of the activity through progressive scene navigation from system overview to detailed synaptic transmission. The subtitle Electrical and chemical signals at work in the synapse highlights the dual perspective of the exercise: the biological side, where neurotransmitters cross the synaptic cleft, and the physical side, where voltage differences trigger the propagation of the impulse. This structure makes the topic interdisciplinary and accessible for an international audience of 14–19 year old students, combining biology and physics in a single interactive scenario. The only addition is "through progressive scene navigation from system overview to detailed synaptic transmission" to reflect your actual implementation method.
Description of the exercises:	Augmented Synapse: Travel Inside the Brain is designed for schoolchildren aged 14–19 to explore the fundamental principles of neural communication through Augmented Reality. The main objective is to help students understand how electrical impulses and chemical signals interact inside the brain and how these processes can be interpreted both from a biological and a physical perspective. The exercise uses AR to guide students through sequential scenes, beginning with an overview of the complete human nervous system, then focusing on two detailed neurons connected by a synapse on the real classroom desk. By tapping interactive elements, students progress through dedicated scenes that demonstrate each stage of synaptic transmission: electrical impulse initiation, neurotransmitter release into the synaptic cleft, and signal reception in the second neuron. The AR experience is enhanced by complementary 3D educational resources accessible through interactive buttons within the AR environment. Students can access detailed anatomical visualizations of "3D Neurons and Nervous Tissue" to explore neuronal structures in depth, and "3D Synaptic Transmission" to examine synaptic mechanisms from additional

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perspectives. These resources serve as preparatory material before the AR experience or follow-up content for deeper anatomical understanding, providing comparative analysis between different visualization approaches.

AR is used here because it allows learners to visualize processes that are usually invisible and abstract. Instead of reading about action potentials and neurotransmitters in a textbook, students navigate through focused scenes showing electrical impulses, neurotransmitters positioned in the synaptic gap, and the resulting activation of the postsynaptic neuron. This step-by-step visualization increases engagement, supports interdisciplinary connections between biology and physics, and simplifies complex concepts.

The exercise opens multiple perspectives: how electrical and chemical processes work together in neural communication, how biological structures can be understood using physical principles of electricity, and how the sequential nature of synaptic transmission ensures reliable brain function. The final stage, where successful communication is demonstrated through visual representation of signal reception, reinforces understanding of the complete synaptic process.

The learning experience concludes with a comprehensive five-question assessment that evaluates student understanding of synaptic transmission sequences, neurotransmitter representation, and the integration of electrical and chemical signals in neural communication. The quiz focuses on conceptual comprehension rather than technical AR interface elements, ensuring students can connect the sequential scene navigation with underlying neurobiological principles and demonstrate mastery of interdisciplinary connections between biology and physics in nervous system function.

Participants:

The exercise is suitable for both individual students and small groups of 3–5 members. Working in groups is recommended to stimulate discussion, compare different observations at each stage of the neural transmission process, and agree on the correct interpretation of the sequential results. Each group can use a single device to interact with the AR scenes, which makes the activity practical even in classrooms with limited equipment.

When carried out individually, the exercise allows each student to explore the AR environment at their own pace and reflect on

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	the sequence of signal transmission through the progressive scenes. In both formats, the activity encourages critical thinking, peer explanation, and responsibility in understanding how biological and physical processes combine to make the nervous system function. The only changes are "at each stage" and "sequential results" to better reflect the scene-by-scene progression, and "through the progressive scenes" to clarify the navigation method you implemented.
Participants' age range:	• Minimum age: 14 years • Maximum age: 19 years To take part in the activity, students should have a basic understanding of biology and physics, in particular the structure of the neuron, the idea of electrical impulses, and the concept of synaptic transmission. These notions are normally introduced in secondary school science courses. No advanced digital skills are required, as Assemblr EDU is intuitive and guided by simple interactions on a smartphone or tablet.
STEM subject and specific topic:	STEM Subject: Biology, Physics, Technology Specific Topic: Neural communication, synaptic transmission, and the relation between biological and physical processes Main challenge of the topic: Students often struggle to visualize how electrical impulses travel along neurons and how neurotransmitters bridge the synaptic gap. These processes are invisible to the naked eye and highly abstract, which makes it difficult to connect the biological explanation with the physical principles of voltage differences and signal propagation. As a result, students tend to memorize terms without truly understanding the sequence of events or their interdisciplinary connections. How AR helps simplify the concept: Through Assemblr EDU, students can interact with 3D models of anatomically accurate neurons connected by a synapse. By navigating through sequential scenes, they observe each stage of synaptic transmission: electrical impulse initiation (represented by visual effects on the first neuron), neurotransmitter release (shown as molecular spheres positioned in the synaptic cleft), and signal reception (demonstrated by electrical activation of the second neuron).

	This step-by-step visualization makes the abstract process concrete, allowing students to understand how electrical and chemical signals work together in sequence. AR thus bridges the gap between theory and observation, reinforcing comprehension and supporting cross-disciplinary learning between biology and physics.
Gamification process:	The gamification strategy follows the recommendations of the BIOS4YOU WP2 guidelines, focusing on challenge-based learning and simple, immediate feedback that can be realistically implemented with Assemblr EDU. • Challenge-based learning: students are given the task of following the complete synaptic transmission process from start to finish. By navigating through each scene, they must understand how electrical impulses initiate, how neurotransmitters are released, and how signals are received to complete neural communication. Each scene progression reveals the next stage of the process. • Immediate visual feedback: instead of points or badges (not supported by Assemblr EDU), feedback is represented through scene transitions and visual representations. Students see the electrical impulse on the first neuron, observe neurotransmitters positioned in the synaptic cleft, and witness the successful activation of the second neuron, demonstrating complete signal transmission. • Role-playing element: learners act as "neural explorers", progressing through the anatomical journey from nervous system overview to detailed synaptic function. In group settings, they discuss their observations at each stage and collaborate to understand the biological and physical principles governing neural communication. This approach combines progressive discovery, visual learning, and narrative exploration to keep students motivated, aligning with the gamification principles defined in the BIOS4YOU WP2 methodology and adapted to the technical possibilities of Assemblr EDU.
Written or graphic description of Augmented info:	The AR experience is developed in Assemblr EDU and includes the following elements: • 3D models of neurons: anatomically accurate MotorNeuron and SensoryNeuron models placed on a real surface such as a classroom desk, with clear synaptic

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	separation. • Scene navigation: by tapping interactive elements, students progress through sequential scenes showing different stages of synaptic transmission. • Electrical impulse representation: Thunder Particle effects positioned on neurons to represent electrical activity at different stages of the process. • Neurotransmitter visualization: molecular spheres positioned in the synaptic cleft to represent neurotransmitters released during synaptic transmission. • Progressive demonstration: students observe the complete sequence from impulse initiation in the first neuron, through neurotransmitter release, to signal reception in the second neuron across dedicated scenes. • Educational information: short text labels and informational content explain each stage (impulse generation, neurotransmitter release, signal transmission) with scientific data including signal speeds and voltage measurements. • Anatomical context: initial scene showing the complete human nervous system provides contextual understanding before focusing on detailed synaptic processes. • Navigation system: "NEXT" buttons and scene transitions guide students through the logical sequence of neural communication. These elements make invisible processes visible and structured, helping students to directly connect biological mechanisms with physical principles of electricity and communication through step-by-step exploration.
External (or extra) tools required	• Devices: smartphones or tablets with the Assemblr EDU app installed (iOS or Android). • AR markers: optional; students can access the AR scene through a QR code or simply use surface detection to place the 3D models of the neurons on a desk. • Printed worksheets: to allow students or groups to record the sequence of events (impulse initiation, neurotransmitter release, receptor activation), reflect on the outcomes, and prepare a short report. • Internet connection: required to access the Assemblr EDU

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Optional:

- Link to external quiz platform (Google Forms/Kahoot) for assessment
- 3D interactive models for complementary learning (mozaweb.com resources)
- Access to supplementary visualizations for deeper understanding of neural structures and synaptic processes

No other physical materials are strictly required. The exercise is designed to be implemented with standard classroom resources and mobile devices.

Links (video, images, text online and so on).

QUIZ
https://docs.google.com/forms/d/e/1FAIpQLSdmXunTg8-vlIU_FyBsFppkFlhtSUJYgjUS-T3cfWnGUF70_Q/viewform?usp=dialog

COMPLEMENTARY 3D EDUCATIONAL RESOURCES

3D Neurons and Nervous Tissue Visualization:

https://www.mozaweb.com/it/Extra-Scene_3D-Neuroni_e_tessuto_nervoso-4024?mode=directlink

Interactive 3D model showing detailed neuronal structures and nervous tissue organization. Can be used as preparatory material before the AR experience or as follow-up resource for deeper anatomical understanding.

3D Synaptic Transmission Visualization:

https://www.mozaweb.com/it/Extra-Scene_3D-Trasmissione_sinaptica-139751?mode=directlink

Detailed 3D visualization of synaptic transmission mechanisms. Complements the AR experience by providing additional perspectives on neurotransmitter release and signal propagation across synapses.

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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 scenario aims to help students understand the sequence of neural transmission and the relationship between biological mechanisms and physical principles. The objectives include distinguishing the main steps of synaptic communication (impulse propagation, neurotransmitter release, receptor activation), recognizing the essential conditions required for successful neural communication, and explaining the events using simple scientific reasoning. Another objective is to promote collaboration, since the activity can be done in small groups, and to strengthen digital competence through purposeful use of AR technology. Overall, the exercise connects scientific knowledge with interdisciplinary reasoning, linking biology, physics, and technology.

Which pedagogical objectives are addressed through this scenario?

Augmented Synapse: Travel Inside the Brain uses AR to make the abstract concept of neural communication more concrete and engaging. Instead of reading about how impulses travel along neurons and cross synapses, students see virtual neurons on their classroom desk and navigate through dedicated scenes showing each stage of the process. By progressing through sequential scenes, they observe electrical impulse initiation, neurotransmitter positioning in the synaptic cleft, and signal reception in the second neuron. This step-by-step exploration allows students to approach biology and physics in a practical way, connecting anatomical structures with electrical and chemical processes through AR technology in a context that feels exploratory and systematic.

Which results are expected to be reached with its use?

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By completing the exercise, students are expected to demonstrate a clearer understanding of how neural signals are transmitted from one neuron to another. They should be able to explain the sequence of events - impulse generation, neurotransmitter release, receptor activation, and continuation of the signal - and recognize the essential biological and physical mechanisms that enable successful neural communication. The activity is also expected to improve engagement: students show greater interest and participation because the invisible processes of the brain become visible and interactive through progressive scene exploration, rather than remaining abstract descriptions in a textbook.

Which benefits are expected to be reached with its use?

The main benefits are increased motivation and deeper comprehension. AR makes learning more interactive, which keeps students focused and curious. The exercise also fosters critical thinking by showing that each stage of neural transmission builds upon the previous one: students observe how electrical impulses lead to neurotransmitter release, which enables signal reception in the second neuron. Working in groups encourages communication and shared interpretation of each scene, while the complete demonstration of successful synaptic transmission provides a sense of understanding and achievement, while external quiz assessment provides quantitative evaluation of learning outcomes and concept retention. These benefits go beyond factual learning, supporting interdisciplinary connections between biology and physics and reinforcing students' confidence in understanding complex scientific processes.

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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://asblr.com/PaQ9a7 The exercise is designed to be implemented entirely with Augmented Reality. It uses markerless AR, since Assemblr EDU allows the placement of 3D objects directly on a detected flat surface such as a classroom desk or the floor.
If it's needed a marker, description of the marker	 No specific marker is required. Students can simply scan a flat surface with their smartphone or tablet camera. As an alternative, a simple QR code can be provided to give direct access to the AR scene.

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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: Assemblr EDU app (free, available on Android and iOS). A PC can be used by teachers for creating or editing the project, but it is not required for student use.
Type of Augmented data	The AR experience integrates different types of content: • 3D models (anatomically accurate MotorNeuron and SensoryNeuron, neurotransmitters represented as molecular spheres, Thunder Particle effects for electrical impulses, complete human nervous system model) • Text overlays (short explanations for each stage: impulse generation, neurotransmitter release, signal reception, with scientific data including voltage measurements and signal speeds) • Scene transitions (progressive navigation from nervous system overview to detailed synaptic transmission, with distinct scenes showing each stage of the neural communication process)
Written description of the AR data	When students open the exercise with Assemblr EDU, they begin with an overview scene showing the complete human nervous system on a real desk surface. By tapping the nervous system model, they navigate to a detailed scene featuring anatomically accurate MotorNeuron and SensoryNeuron models positioned with clear synaptic separation. Students then progress through sequential scenes by tapping interactive elements: first observing electrical impulse initiation (represented by Thunder Particle effects on the MotorNeuron), then neurotransmitter release (shown as molecular spheres positioned in the synaptic cleft), and finally signal reception (demonstrated by Thunder Particle effects on the SensoryNeuron). Throughout each scene, explanatory text overlays and informational content provide key scientific data about each stage of the process (impulse generation, neurotransmitter release, signal transmission), including voltage measurements and signal speeds. The step-by-step scene navigation allows students to understand the complete sequence of successful synaptic transmission, followed by access to an external assessment quiz (Google Forms) for evaluation of synaptic transmission comprehension.

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If Image	If the AR data are Images, the formats needed are .jpg, and .png (better size < 2Mb) (*)
If Text	Short explanatory messages (e.g. "THE HUMAN NERVOUS SYSTEM", "ELECTRICAL IMPULSE ACTIVATED", "SIGNAL SUCCESSFULLY TRANSMITTED", "Get closer and tap") are displayed as overlays inside Assemblr EDU. An additional overlay with the text "QUIZ" is displayed, providing an external link to the Google Form: https://docs.google.com/forms/d/e/1FAIpQLSdmXunTg8-vlIU_FyBsFppkFlhtSUJYgjUS-T3cfWnGUF70_Q/viewform?usp=dialog **What was the correct sequence of scenes in the AR experience?** • Detailed neurons → Human nervous system → Signal transmission • Human nervous system → Detailed neurons → Signal transmission (RIGHT) • Signal transmission → Detailed neurons → Human nervous system • Detailed neurons → Signal transmission → Human nervous system **How were neurotransmitters represented in the AR experience?** • As lightning bolts crossing between neurons • As colored molecular spheres in the synaptic cleft (RIGHT) • As glowing waves traveling along axons • As mathematical equations on screen **According to the AR experience, synaptic transmission involves:** • Only electrical signals • Only chemical signals • Both electrical and chemical signals (RIGHT) • Neither electrical nor chemical signals

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	What represented electrical impulses in the neurons? • Thunder Particle effects (RIGHT) • Molecular spheres • Text overlays • Color changes **What is the correct sequence of synaptic transmission steps as shown in the AR experience?** • Chemical signal → Electrical signal → Reception • Electrical signal → Chemical signal → Reception (RIGHT) • Reception → Chemical signal → Electrical signal • Chemical signal → Reception → Electrical signal
If video	-
If audio	-
If 3D model	3D models are needed in formats compatible with Assemblr EDU (.glb, .obj). These include anatomically accurate MotorNeuron and SensoryNeuron models from Assemblr's library, complete human nervous system model, molecular spheres representing neurotransmitters, Thunder Particle effects representing electrical impulses, and PNG button images for navigation between scenes.

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