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"Lab-Grown Organs: Can We Print a New Heart?"

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

Project Number: KA220-BW-23-30-126516

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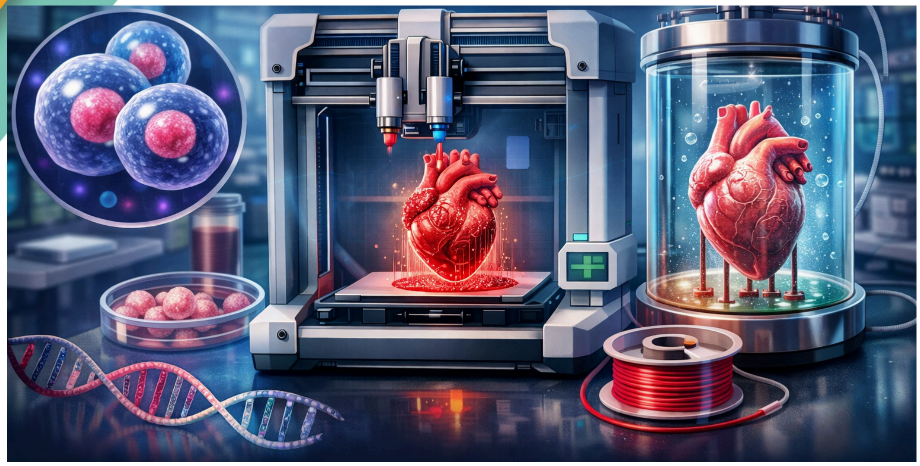

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General topic of the learning path	Biotechnology and Regenerative Medicine
Specific name of the learning unit	Lab-Grown Organs: Can We Print a New Heart?
Age of the target users	14-18 years
Requirements for the learner	• Basic knowledge of human biology (cells, tissues, organs). • Basic digital literacy and familiarity with using a computer, tablet, or smartphone. • Access to an internet-connected device. • No prior knowledge of bioengineering, stem cells, or Augmented Reality is required.
Description of the learning unit	This learning unit introduces students to the emerging field of regenerative medicine, focusing on lab-grown organs and 3D bioprinting technologies. Through a bio-inspired STEM approach and the use of Augmented Reality, students explore how living cells can be used to repair or replace damaged tissues and organs. The unit combines scientific foundations with interactive AR-based learning activities using Delightex Edu, helping learners understand both the biological principles and technological challenges behind organ engineering.
Subject: Parties involved	Biology, Biotechnology, Technology, Engineering, Digital Literacy, STEM Education
Keywords	Regenerative medicine, Stem cells, Lab-grown organs, 3D bioprinting, Tissue engineering, Bio-inspiration, Augmented Reality (AR), Delightex Edu
Key qualifications, skills and knowledge that can be acquired	• Understanding the basic principles of regenerative medicine and stem cell biology. • Awareness of how bio-inspired technologies are used to grow tissues and organs. • Critical thinking about ethical, medical, and technological challenges. • Digital and scientific literacy through AR-based exploration.

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	• Ability to connect biology with real-world medical innovations.
Resources and didactic aids used	• Mobile devices or tablets with AR capabilities. • Computers with internet access. • Delightex Edu, AR/VR platform. • 3D models of cells, tissues, and organs. • Teacher-prepared supporting materials (texts, images, videos).
Assessment criteria and evaluation	• Participation in discussions and AR-based activities. • Completion of interactive tasks and exercises. • Ability to explain key concepts related to lab-grown organs and bioengineering. • Reflective discussion and formative feedback.

Introduction

This learning unit explores how scientists are using bio-inspired technologies, such as stem cells and 3D bioprinting, to grow organs in the laboratory. By combining biology, technology, and Augmented Reality, students gain insight into how lab-grown organs could transform modern medicine and address real-world health challenges.

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Explore - Understanding Natural Regeneration and Bio-Inspired Organ Growth

In this section, students are introduced to the scientific foundations of regenerative medicine and lab-grown organs. They explore how nature repairs itself, how scientists use stem cells to regenerate tissues, and how bio-inspired technologies such as 3D bioprinting aim to recreate complex human organs.

The Explore phase provides essential background knowledge needed to understand both the potential and the limitations of organ printing.

1.1 How the Body Repairs Itself: Regeneration in Nature

Living organisms have a natural ability to repair and regenerate damaged tissues. Human skin heals after injury, bones can regrow after fractures, and some animals—such as salamanders—can regenerate entire limbs.
This natural regeneration is possible because:

- cells can divide and replace damaged ones,
- specialized cells work together to rebuild tissue,
- biological systems follow organized growth patterns.

Regenerative medicine is inspired by **nature's own repair mechanisms**.

1.2 Stem Cells: The Building Blocks of Regenerative Medicine

Stem cells are special cells with two unique abilities:

- they can self-renew (make more stem cells),
- they can differentiate into different cell types (muscle, nerve, blood).

In regenerative medicine, stem cells are used to:

- grow new tissue,
- repair damaged organs,
- study diseases in laboratory conditions.

Unlike ordinary cells, stem cells act as biological "starting points", making them essential for growing lab-made tissues and organs.

1.3 From Cells to Tissues: How Living Structures Are Formed

Organs are not made of single cells but of organized tissues. Cells communicate, align, and connect to form structures that can perform specific functions.
For example:

- heart muscle cells must contract together,
- blood vessels must deliver oxygen and nutrients,

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- tissues must survive and adapt in a living environment.

This process shows that structure and function are closely linked in biology—a key challenge when trying to recreate organs in the laboratory.

1.4 Bio-Inspiration and 3D Bioprinting

Scientists use bio-inspiration to design technologies that mimic natural processes. One such technology is 3D bioprinting, where layers of living cells are placed in specific patterns to form tissue-like structures.
Unlike plastic 3D printing:

- living cells must stay alive,
- tissues need nutrients and oxygen,
  structures must grow and adapt over time.

Bio-inspiration helps engineers understand how nature builds complex systems, guiding the development of lab-grown organs.

Suggested video resource:
To better understand how bio-inspired technologies and 3D bioprinting are used in regenerative medicine, students are encouraged to watch the following short videos, which illustrate real-world research and current challenges in lab-grown organs:

- https://www.youtube.com/watch?v=ABgehFQu8eU
- https://www.youtube.com/watch?v=yh8IQPjD4Og

To better understand how bio-inspired technologies are used to grow tissues and organ-like structures in the laboratory, students are encouraged to watch the following short video. It illustrates the key steps involved in tissue engineering and bioprinting, helping to connect biological principles with technological processes.

- https://www.youtube.com/watch?v=2NFsvn9q9hA

1.5 Can We Print a Human Heart?

The human heart is one of the most complex organs in the body. It must:

- pump continuously,
- contain multiple tissue types,
- include a dense network of blood vessels,
- work in perfect coordination.

While scientists have successfully grown simple tissues and small organ models, printing a fully functional human heart remains a major scientific challenge.
Just because something is possible in theory does not mean it is fully achievable today.

Suggested 3D visualization resources:
To better understand the dynamic structure and function of the human heart, students are

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encouraged to explore the following animated 3D heart models. These visualizations help illustrate why recreating a fully functional heart is one of the greatest challenges in regenerative medicine.

https://sketchfab.com/3d-models/3d-animated-realistic-human-heart-v20-168b474fba564f688048212e99b4159d
https://sketchfab.com/3d-models/human-heart-3d-animated-911272d9f7c146bea5403d1e4d2dfb31

1.6 Questions for Reflection

- How does nature regenerate tissues and organs?
- Why are stem cells important in regenerative medicine?
- What makes the human heart difficult to recreate in the laboratory?
- How does bio-inspiration guide medical innovation?

Execute

2. Applying Bio-Inspired Principles to Lab-Grown Organs

In the Execute section, students apply their understanding of regenerative medicine by exploring how natural biological processes inspire solutions for growing tissues and organs in the laboratory.

Through hands-on, AR-supported activities using Delightex Edu, learners investigate how cells form tissues, why organs are complex systems, and what challenges scientists face when attempting to print a functional human heart.

2.1 Bio-Inspiration: Learning from Natural Regeneration

Nature provides powerful examples of regeneration and self-repair that inspire modern biomedical technologies:

- **Cell renewal and differentiation** allow damaged tissues to be repaired.
- **Self-organization** enables cells to arrange themselves into functional tissues.
- **Network formation**, such as blood vessels, supports survival and growth.

Students explore how these natural abilities guide the development of tissue engineering and lab-grown organs, reinforcing the idea that medical innovation often begins by observing nature.

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2.2 How Augmented Reality Supports the Learning Objectives

Augmented Reality plays a key role in helping students understand processes that cannot be directly observed in real life.
Using **Delightex Edu**, AR activities allow students to:

- visualize **stem cells, tissues, and organ** structures in 3D,
- explore **layered organ models**, such as the human heart,
- observe how **cells, tissues, and blood vessels** interact as a system,
- compare **biological regeneration** with 3D bioprinting technologies.

AR makes abstract biomedical concepts more accessible and supports inquiry-based learning without requiring advanced laboratory equipment.

2.3 Practical Activities (Overview)

- **Activity 1: From Stem Cells to Tissue**

Students explore AR models of stem cells and cell division.They observe how cells multiply and specialize, discussing why stem cells are essential for growing new tissues.
Bio-inspired concept: Natural regeneration and cell differentiation.

- **Activity 2: Why the Heart Is Difficult to Print**

Using a layered AR model of the human heart, students examine:

- muscle tissue,
- chambers and valves,
- blood vessel networks.

They analyze why all these components must work together and why recreating this complexity is challenging.

Supporting video resource:
Before analyzing the layered AR model of the heart, students watch a short video demonstrating how the human heart functions in real time. This resource supports understanding of the continuous movement and coordination required for a functional organ.
https://www.youtube.com/watch?v=mMeOjwH4NVU

Bio-inspired concept: Structure–function relationship in living systems.

- **Activity 3: Printing vs. Growing Living Tissue**

Students compare:

- a simple 3D-printed object,
- a living tissue model created from cells.

They identify key differences between printing non-living materials and growing living organs.
Bio-inspired concept: Difference between mechanical construction and biological growth.

- **Activity 4: Decision Task – Can We Print a Heart Today?**

Students complete an AR-based decision activity where they:

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- evaluate current scientific possibilities,
- identify technological and biological limitations,
- distinguish between present-day medicine and future potential.

Bio-inspired concept: Scientific reasoning based on biological constraints.

- **Activity 5: Designing a Functional Organ – Why Structure Matters**

Using an interactive AR organ model in Delightex Edu, students explore how different structural components contribute to organ function. By activating and deactivating layers and elements, learners analyze how organs operate as integrated systems rather than simple shapes. This activity highlights why lab-grown organs must replicate biological organization, not just external form.

Bio-inspired concept: Structure–function relationships and systems thinking in living organisms.

Through bio-inspired, AR-supported activities, students move from understanding concepts to ***applying biological thinking****. They experience how regenerative medicine combines biology, technology, and engineering, and why growing a human heart is not just a technical challenge, but a biological one.*

Enhance

3. Enhancing Understanding of Regenerative Medicine through Augmented Reality

The Enhance section explains how Augmented Reality (AR) deepens students' understanding of regenerative medicine by making complex biological processes visible, interactive, and meaningful. In this unit, AR is used to support learning about lab-grown organs by allowing students to explore biological structures and bio-inspired technologies that cannot be accessed in a traditional classroom.

3.1 How AR Strengthens Learning about Lab-Grown Organs

Topics such as stem cells, tissue regeneration, and organ complexity are often abstract and difficult to imagine. AR helps overcome these challenges by transforming scientific concepts into tangible visual experiences.

Through AR-supported learning, students can:

- observe cell-to-tissue formation in three dimensions,
- explore layered organ structures, such as the human heart,

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- understand the role of blood vessel networks in sustaining living tissue,
- recognize the difference between growing living tissue and printing non-living objects.

This visual and interactive approach supports deeper conceptual understanding and reduces cognitive overload.

3.2 Delightex Edu as a Tool for AR-Enhanced Learning

Delightex Edu is well suited for this unit because it enables both exploration and creation within a safe educational environment.
Using Delightex Edu, students and teachers can:

- interact with ready-made 3D biological models of cells, tissues, and organs,
- explore AR scenes using markerless AR or QR codes,
- follow guided learning paths without advanced technical skills,
- work individually or collaboratively on AR-based tasks.

The platform allows learners to actively engage with content, strengthening motivation and ownership of learning.
In this unit, Delightex Edu is also used to support systems-based learning through interactive organ models, allowing students to explore how structural components interact to enable or limit organ functionality.

Suggested multimedia resource:
To illustrate how Augmented Reality can be used to explore human anatomy in three dimensions, students can watch the following short video demonstrating Delightex Edu visualizations of human organs. This resource supports understanding of organ structure and spatial relationships, which are essential when discussing lab-grown organs.

https://www.facebook.com/delightexedu/videos/human-anatomy/715913087136373/

3.3 Increasing Engagement through Gamification and Interaction

AR-based activities in this unit include light gamification elements that enhance engagement while keeping the focus on learning:

- Points and badges for completing exploration tasks and decision activities,
- Scenario-based challenges related to regenerative medicine,
- Collaborative discussion tasks where students compare decisions and outcomes.

Gamification encourages participation, reflection, and teamwork without distracting from scientific content.

3.4 AR-Based Reflection and Assessment

Augmented Reality also supports formative assessment and reflection. Instead of relying only on written tests, students demonstrate understanding through interaction and discussion.
Teachers can assess learning by observing:

- how students explore AR models,

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- how they explain biological processes and challenges,
- how they justify decisions in ethical and scientific scenarios.

This approach values understanding, reasoning, and application over memorization.

By integrating Augmented Reality through Delightex Edu, this learning unit makes regenerative medicine accessible, engaging, and relevant. AR supports deeper understanding of bio-inspired organ growth, strengthens the connection between biology and real-world medical challenges, and encourages students to think critically about the future of lab-grown organs.

Conclusion

This learning unit guided students through the Explore–Execute–Enhance phases to understand how lab-grown organs are developed using bio-inspired principles from nature. Students explored natural regeneration and stem cell biology, applied this knowledge through AR-supported activities, and deepened their understanding of the complexity of growing a functional human heart. The use of Augmented Reality tools, particularly Delightex Edu, made abstract biological and technological concepts more accessible and engaging. By connecting regenerative medicine with real-world medical challenges, the unit encourages students to reflect on both the possibilities and limitations of organ printing and to continue exploring future innovations in biomedical science.

Phase	Description
Explore	- Research and Discovery: Students investigate how living organisms naturally regenerate tissues and how these biological processes inspire regenerative medicine. They explore the role of stem cells, tissue formation, and the complexity of human organs, focusing on why the heart is particularly challenging to recreate.
	- Content Development: Key concepts are introduced, including natural regeneration, stem cell differentiation, tissue organization, bio-inspiration, and the principles of 3D bioprinting. Scientific explanations are supported by examples from nature and current biomedical research.
	- Needs Analysis: Students' prior knowledge of basic biology (cells, tissues, organs) and general understanding of health and medicine is identified through guiding questions and discussion. This ensures appropriate scaffolding for learners aged 14–18.
Execute	- Curriculum Implementation: Students apply theoretical knowledge through bio-inspired, hands-on activities that demonstrate how cells form tissues and why organs function as complex systems. The focus is on understanding processes rather than technical laboratory procedures.
	- Interactive Exercises: Using Delightex Edu, students interact with AR models of stem cells, heart anatomy, blood vessel networks, and layered organ systems, exploring how biological structures function as integrated systems.

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	. They explore layered organ structures, compare biological growth with 3D printing, and complete decision-based scenarios related to lab-grown organs.
	- Feedback Collection: Immediate visual feedback is provided through AR interactions. Learning is reinforced through group discussion, teacher-guided reflection, and peer feedback during and after the activities.
Enhance	- AR Integration: Augmented Reality is used to visualize biological structures and processes that cannot be directly observed in the classroom. Delightex Edu enables markerless AR exploration of cells, tissues, and organs, supporting inclusive and experiential learning.
	- Interactive Learning: Students actively explore, manipulate, and analyze 3D models, encouraging inquiry-based learning and systems thinking. AR supports experimentation, comparison, and reflection on real-world biomedical challenges.
	Gamified Content: - **Points and Badges**: Students earn points for completing exploration tasks and receive badges such as Tissue Engineer or Future Doctor for achieving learning milestones. - **Leaderboards**: Optional group-based leaderboards display collective progress, encouraging motivation while emphasizing collaboration rather than competition. - **Quests and Levels**: Learning activities are structured as progressive quests, moving from cell-level exploration to organ-level understanding, with increasing complexity. - **Rewards for Exploration**: Visual rewards and positive feedback are provided for thorough investigation and thoughtful decision-making within AR activities. - **Collaborative Gamified Tasks**: Students work in small groups to analyze scenarios, discuss challenges, and agree on decisions related to lab-grown organs and ethical considerations.
	AR-Based Assessments: Students demonstrate understanding through interaction with AR models, completion of tasks, and explanation of biological and technological concepts. Assessment focuses on reasoning, application of knowledge, and reflection rather than memorization.

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AI-based tools (ChatGPT, Perplexity AI, and NotebookLM) were used to support content drafting, research synthesis, and organization of source materials during the development of this learning unit:

- *ChatGPT* (large language model). https://chat.openai.com
- *Perplexity AI* [AI-powered search and research assistant]. https://www.perplexity.ai
- Google *NotebookLM* [AI-powered research and note-taking tool]. https://notebooklm.google.com

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