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15_The MSC for the treatment of rheumatoid arthritis

BIOS4YOU AR 2.0

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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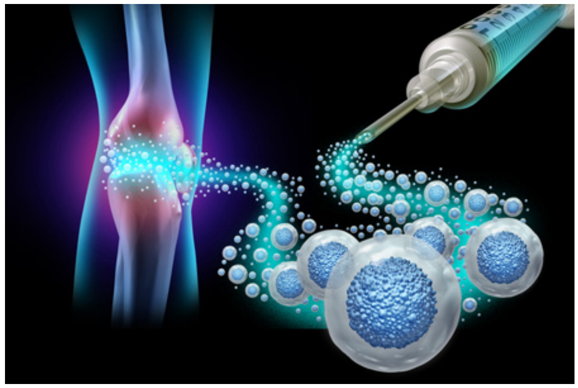

General topic of the learning path	The broader theme of this learning path is Biotechnology and Regenerative Medicine, focusing on how science can use the body's natural repair mechanisms to treat disease and restore health. Students explore how biology, technology, and ethics meet in real-world medical innovations.
Specific name of the learning unit	Stem Cells in the Medical World
Age of the target users	14-18 years
Requirements for the learner	• Have basic knowledge of biology, especially the structure and role of cells. • Be curious about medical applications of science. • Be able to work collaboratively in groups and use digital tools (such as AR applications or online resources). • Be open to discussing ethical issues related to biotechnology.
Description of the learning unit	This learning unit introduces learners to **stem cells**, unique cells capable of both self-renewal and differentiation into specialized cells. Students will: **Explore, Execute, Enhance.** The narrative journey helps students move from abstract knowledge to applied understanding, connecting classroom learning to real-world challenges in healthcare.
Subject: Parties involved	Subjects: Biology, Health Science, Ethics, ICT.

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	Parties involved: Students, teachers, possible guest experts (medical researchers or bioethics speakers).
Keywords	Stem Cells, Regenerative Medicine, Cell Therapy, Differentiation, Tissue Repair, Biotechnology, Ethics, Augmented Reality.
Key qualifications, skills and knowledge that can be acquired	**Knowledge** • Types of stem cells: embryonic, adult, iPSCs. • Functions: self-renewal & differentiation. • Medical uses: bone marrow transplants, corneal repair, regeneration trials. • Ethical debates: embryonic stem cell use. **Skills** • Case study analysis. • AR simulations for cell processes. • Scientific communication & teamwork. • Critical thinking on bioethics. **Competences** • Applying biology to medical challenges. • Assessing biotechnology's social impact. • Responsible, reflective use of new technologies.
Resources and didactic aids used	Video resources, Online learning platforms, AR applications, Interactive tools
Assessment criteria and evaluation	Assessment combines knowledge, practice, creativity, and reflection

Introduction

Stem cells give us hope that many diseases will be curable in the future. In fact, thanks to them, we can imagine a future in which a heart damaged by a heart attack can be repaired, in which blindness caused by a corneal injury can be cured, or in which people with paralysis can walk again. These scenarios may seem like science fiction, but they are at the heart of cutting-edge research on **stem cells**.

Unlike most cells in the body, which are locked into a single identity, stem cells are different. They are nature's “master builders”: capable of both creating endless copies of themselves and transforming into many specialised cells - blood, nerves, skin or muscle. By studying and harnessing these extraordinary cells, doctors and scientists hope to

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discover powerful new ways to treat disease, repair tissue and perhaps even regenerate entire organs.

This teaching unit invites students to explore the world of stem cells using the **three E's methodology**:

- **Explore**: build a solid foundation of knowledge about stem cells and their role in medicine.
- **Experiment**: experience how stem cells work through **interactive augmented reality (AR) simulations** and real-life case studies.
- **Enhance**: deepen understanding by reflecting on advanced applications, ethical issues and the future of regenerative medicine.

In addition, this methodology will be implemented with practical exercises on how to use Augmented Reality technology.

Upon completion, students will not only understand what stem cells are and how to use AR technology, but also how science is trying to use them to solve some of the biggest challenges in healthcare.

Every human body is made up of trillions of cells, each with a specific role: muscle cells contract, skin cells protect, and nerve cells transmit signals. Most of these cells are *specialised*: once they become a certain type of cell, they cannot change.

Stem cells are different.

They are the **master builders** of the body. Their two unique abilities are:

Self-renewal: they can divide and create copies of themselves many times.

Differentiation: they can transform into many different types of specialised cells, depending on the body's needs.

There are several main types of stem cells:

- **Embryonic stem cells (ESCs):** These are found in early-stage embryos. They are **pluripotent**, meaning they can become any type of cell in the body: muscle, nerve, skin or blood. This makes them powerful, but also controversial, because harvesting them involves destroying the embryo.

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- Adult stem cells: These are found in tissues such as bone marrow, skin, or fat. They are multipotent, meaning they can become only certain types of cells. For example, bone marrow stem cells can produce blood cells, but not brain cells.
- **Induced pluripotent stem cells (iPS):** a revolutionary discovery. In 2006, scientists Shinya Yamanaka and Kazutoshi Takahashi discovered how to take normal adult cells (such as skin cells) and “reprogram” them to act like embryonic stem cells. This means that scientists can now create pluripotent cells without embryos.

In simple terms, it is important to understand that stem cells are like blank Lego bricks. They can create copies of themselves or be moulded into many different pieces to build what the body needs.

Examples of stem cell applications

- **Blood disorders:** Bone marrow stem cell transplants are used worldwide to treat leukaemia, lymphoma and sickle cell anaemia (Mayo Clinic, 2023).
- **Eye diseases:** Corneal stem cell therapy has restored vision in patients with severe eye damage (NIH, 2022).
- **Heart repair:** Clinical trials are testing whether stem cells can regenerate damaged heart muscle after a heart attack.
- **Neurodegenerative diseases:** Researchers are exploring stem cell therapies for Parkinson's and Alzheimer's disease, although these are still in the experimental stage.
- **Regenerative medicine:** In the future, scientists hope that stem cells can be used to grow new organs for transplantation.

Additional material to use:

https://youtu.be/9db44fBrWrE

https://www.khanacademy.org/test-prep/mcat/cells/cellular-development/v/stem-cells?utm_source=chatgpt.com

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https://gizmodo.com/grow-stem-cells-with-shrinky-dinks-and-a-pipette-367796

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.

Execute:

Once the foundations have been laid, learning becomes practical. Students enter a virtual augmented reality laboratory, where they can see processes

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that are normally invisible. A 3D model of human tissue floats in front of them. They zoom in on the image until they reach the cellular level, where stem cells are ready to be guided.
The AR environment sets missions. In one of these, a heart muscle has been damaged after a heart attack. Students are tasked with applying stem cells to regenerate the damaged area. They drag and drop the cells into the correct position and watch as the tissue slowly repairs itself. In another mission, they treat a patient with leukaemia by transplanting bone marrow stem cells. Step by step, the AR narrates what is happening: the stem cells divide, become healthy blood cells, and the patient heals.
These digital missions mirror real-world medical applications. In Europe, for example, doctors have already transplanted stem cells into patients with corneal damage to restore their sight. In laboratories around the world, scientists are experimenting with stem cell therapy for Parkinson's disease and spinal cord injuries.
Through these exercises, students don't just memorise facts, they experience science. And because the AR system provides immediate feedback, they know right away if they've chosen the right stem cells, applied them to the right tissues, or if something has gone wrong.
To consolidate the experience, each student keeps a digital lab journal, noting successes, challenges, and reflections. Group work and peer discussion reinforce the spirit of collaboration, transforming the virtual lab into a shared learning adventure.

Enhance:

Once they have acquired the basics and completed the practical simulations, students are encouraged to think big. Augmented reality becomes a tool for exploring questions such as “what if...”. What if stem cells did not integrate properly? What if they formed tumours instead of healthy tissue? What if one day they could reconstruct entire organs?
At this stage, students use augmented reality to simulate more complex scenarios, such as designing therapies for neurological diseases or testing

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how induced pluripotent stem cells (iPSCs) could replace embryonic stem cells to avoid ethical controversies. They also explore **bio-inspiration**: animals such as salamanders can regrow entire limbs, could stem cell science help humans achieve something similar one day?

Learning is also gamified to keep students engaged. They earn **points and badges** for successfully completed missions, climb the **leaderboards** for creative problem solving, and unlock new **missions and levels** as they treat more complex "virtual patients". Collaborative challenges encourage teamwork: groups may be tasked with saving a digital patient with multiple organ damage, requiring them to pool their knowledge and strategies.

Assessment is integrated into augmented reality activities. Instead of taking a paper test, students demonstrate what they have learned by repairing tissue, explaining the steps they took and reflecting on the results.

Teachers use augmented reality logs, group presentations and diaries to assess not only knowledge, but also skills, creativity and ethical reasoning.

Conclusion:

By the end of this unit, students will have:

- **Explored** the science of stem cells and their unique ability to repair and regenerate.
- **Performed** interactive missions in an AR laboratory, where they experienced how stem cells can cure diseases and rebuild tissue.
- **Enhanced** their understanding by simulating advanced scenarios, reflecting on ethics, and engaging in gamified teamwork.

Augmented reality transformed abstract biology into something students could **see, touch, and manipulate**. Ethical debates connected science to society, making the topic relevant to their lives and futures. Most importantly, students gained an understanding of both the **potential and responsibility** that come with technologies such as stem cell therapy.

This unit demonstrates that learning science is not just about reading facts, but also about living the questions, experimenting with possibilities, and

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imagining a future where bio-inspiration helps us solve real-world challenges.

Phase	Description
Explore	- Research and Discovery: Students begin by discovering what makes **stem cells unique** compared to ordinary body cells. While most cells are specialized for one job (skin cells protect, nerve cells transmit signals), stem cells are different: they can both **self-renew** (make endless copies) and **differentiate** (transform into many types of cells). Through simplified readings, videos, and teacher-guided discussion, learners are introduced to the three main categories: **embryonic stem cells** (pluripotent, able to become any cell), **adult stem cells** (multipotent, tissue-specific), and **induced pluripotent stem cells (iPSCs)**, reprogrammed from adult cells (Takahashi & Yamanaka, 2006).
	- Content Development: Key content is presented through real-world medical examples: ● **Bone marrow transplants** for leukemia and lymphoma. ● **Corneal stem cells** restoring sight (NIH, 2022). ● Research into **heart tissue regeneration** after heart attacks (Mayo Clinic, 2023). This stage builds the **knowledge foundation**: stem cells = the body's natural repair system, with huge potential in medicine.
	- Needs Analysis: Students need to: ● Understand the **basic biology** of stem cells. ● Visualize the **process of harvesting, preparing, and transplanting** stem cells. ● Recognize the **social and ethical questions** (use of embryonic cells, accessibility of therapies). This prepares them for more advanced, interactive exploration in the next phase.
Execute	- Curriculum Implementation: Students move from theory into practice through a **virtual AR laboratory**, where they can "see" stem cells in action. They are transported into a digital model of the human body, zooming in to the cellular level to watch how stem cells divide, differentiate, and repair tissue.
	- Interactive Exercises: Learners complete mission-based AR activities, such as: 1. **Treating leukemia** by transplanting bone marrow stem cells into a virtual bloodstream. 2. **Repairing a damaged cornea** by applying corneal stem cells and watching vision return. 3. **Regenerating heart muscle** by placing stem cells on damaged cardiac tissue after a "virtual" heart attack. In addition, students work in groups to analyze case studies of real stem cell therapies worldwide and role-play as researchers presenting findings to the class.
	- Feedback Collection: The AR application provides immediate feedback: ● Did the student choose the correct type of stem cell? ● Did the treatment succeed? ● How many attempts were needed? Teachers collect AR activity data, while students reflect in **digital lab journals**, noting their successes, failures, and questions. Peer feedback adds another layer of evaluation, with groups reviewing each other's strategies and conclusions.

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<tr>
<td rowspan="4">Enhance</td>
<td>- AR Integration:
Here, AR is used not just to demonstrate but to deepen learning. Learners test advanced scenarios:
● What happens if transplanted cells don’t integrate correctly?
● Could stem cells grow entire organs for transplant?
● How do iPSCs change the ethical debate?
The ability to visualize microscopic processes in 3D makes complex concepts accessible, bridging theory and real-world application.</td>
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<td>- Interactive Learning:
Beyond simulations, learners reflect on broader issues:
● Applications: treating diseases, repairing tissues, advancing regenerative medicine.
● Limitations: costs, risks of tumors, integration challenges.
● Ethics: Should embryonic stem cells be used? How do we ensure equal access to therapies?
Classroom debates and reflective writing connect science with society.</td>
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<td>Gamified Content:
- Points and Badges: earned for completing AR missions correctly.
- Leaderboards: tracking team progress in simulations and case study challenges.
- Quests and Levels: each successful therapy unlocks a new, more complex mission (from single-tissue repair to multi-organ regeneration).
- Rewards for Exploration: bonus points for testing innovative solutions or linking examples from current research.
- Collaborative Gamified Tasks: groups must combine their knowledge to save a “virtual patient” with multiple problems.</td>
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<td>AR-Based Assessments:
● Students demonstrate mastery by completing simulated stem cell treatments.
● They explain their decisions step by step within the app or in presentations.
● Teachers evaluate performance based on accuracy, reasoning, collaboration, and reflection in journals.</td>
</tr>
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