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# Sickle cell in the treatments of anemia and thalassemia



**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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# Introduction

The purpose of this document is to create guidelines to help the project staff that are dealing with school children, 14-19 aged, to create and re-adapt exercises using Augmented Reality technology.

To this end, a series of templates have been created that define exercises from a methodological, pedagogical and technological point of view.

A good written description, along with images, videos or sketches of the exercise is very important for experts to understand the idea. This will be part of the “General Information” template.

On the other hand, it will be important to define what STEM topic/subject each exercise is intended for and how AR technology can help students or staff or people interested in it when they use these exercises. In addition, people interested in the exercise can understand the usefulness of augmented information, and it will be necessary to explain the benefits.

During the process of defining the augmented information that each exercise will offer, staff working with teachers will be able to develop innovative ideas that make it easier to learn teaching concepts in an easier way.

All students will be able to view the contents explained by professionals projected in the real world in the form of text, 3D model, image, video, sound... This will help them focus their attention on exercise and more easily assimilate the associated concepts.

This document consists of the following points:

- Information about AR technology
- How to define AR exercise thanks to the template:
  - General information



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- Pedagogical specifications
- Technical specifications

# General information

In this part it will be necessary to report the generic information of the exercise so that it can be recognised.

Name of the exercise:

Sickle cell anemia and thalassemia

Description of the exercises:

The activity uses augmented reality to understand, through a series of interactive questions, how certain forms of thalassaemia can be treated using gene therapy.

Participants:

The activity is designed to be done **individually**, with optional group reflection afterward. Individual participation ensures that each student makes their own decisions throughout the experience, fostering personal curiosity.

Group discussions at the end (optional) allow comparison of results and reasoning behind choices, strengthening collaborative learning and peer feedback.

Participants' age range:

Minimum age: 17, Maximum age: 19

The exercise assumes prior basic knowledge of science. Students at this age are cognitively ready to engage in abstract thinking, ethical reasoning, and real-world problem-solving.



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STEM subject and  
specific topic:

The exercise tackles the challenge of making complex gene therapy understandable through playful education. Augmented reality helps simplify this aspect by showing each step in a clear and interactive way.

Gamification  
process:

Written or graphic  
description of  
Augmented info:

Students interact with Dr Alex, who asks them to save a patient using this new gene therapy. Every decision made by the student reflects their ability to learn quickly.

Information overlay: decision requests and visual feedback effects.

Floating 3D choices: students select the correct answer.

Static AR environments: an interactive test.

The AR experience is anchored through image recognition or QR markers and does not require any physical movement: it is designed to be used on a desk or school bench.

External (or extra)  
tools required

Mobile device or tablet with AR capabilities. Internet connection for initial file loading. Printed AR marker sheet (optional) or screen-displayed trigger image.

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

<https://www.ellenmacarthurfoundation.org/>

## BIO-INSPIRED AR 2.0

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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?

Using a mobile device (tablet or phone), students will scan the QR code that will take them into the game. Once inside, they will need to talk to the protagonist and will be able to navigate their surroundings.

Which pedagogical objectives are addressed through this scenario?

The educational objective of this game is to improve students' logical skills. Students will have to imagine the situation they find themselves in and respond with the knowledge they acquire in real time.



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### Which results are expected to be reached with its use?

Anaemia and thalassaemia are two common diseases that require greater awareness and knowledge. Applying the knowledge currently developed at school and integrating new research in the field improves students' curiosity about the subject.

### Which benefits are expected to be reached with its use?

Students can improve their technical and IT skills through the use of augmented reality. By improving their proprioception and gestures, they can acquire greater skills for their future. The game mode will make the educational experience more enjoyable, improving empathy when dealing with challenging and difficult-to-understand topics.



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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/Studio/Space/3iHSB5FEyFHnStnW>

Marker

If it's needed a marker, description of the marker



Hardware and software needed:

pc, smartphone, tablet, camera.

Type of Augmented data

Images; Text; 3D models



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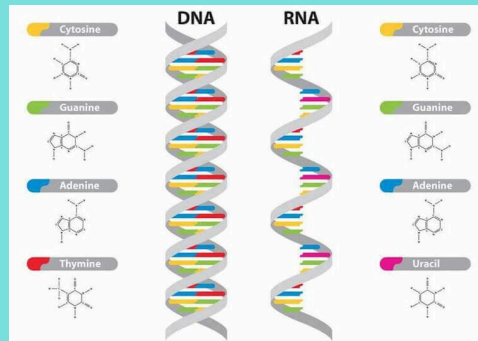
Written description of  
the AR data

Students will begin the experience by scanning a marker or accessing an AR app on their mobile device or tablet. The building will appear on the screen with Dr Alex at the entrance, who will invite the student to participate in the application of the therapy.

One by one, students will learn how this disease works and how to intervene through specific and logical questions.

The activity is carried out individually, but can conclude with a class discussion or reflection to compare results and share insights.

If Image



If Text



## Genetic Mission: Save Sofia

[Cover image: laboratory/hospital]

Hello Doctor Alex!



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Welcome to the Advanced Gene Therapy Center. Today begins an extraordinary mission that could change a young patient's life.

## Meet Sofia

Sofia is 16 years old and loves playing volleyball, but **beta-thalassemia major** prevents her from living a normal life. Every 2-3 weeks she needs blood transfusions because her body doesn't produce enough functional hemoglobin.


The problem? A genetic mutation inherited from her parents.

## The solution: CRISPR-Cas9

You have access to the most revolutionary technology in modern medicine: **CRISPR-Cas9**, the "molecular scissors" that allow us to rewrite DNA.

Your goal: modify Sofia's stem cells to reactivate fetal hemoglobin production, which works perfectly even in adults!

**Are you ready to begin?**

 **Fun fact:** CRISPR stands for "Clustered Regularly Interspaced Short Palindromic Repeats" - but don't worry, nobody calls it that!

[BUTTON: START PHASE 1 →]

## PHASE 1: Collecting stem cells

[Image: stem cells or bone marrow]

Sofia is ready for the first step. You need to harvest the hematopoietic stem cells that will then be modified with CRISPR.

These special cells are the "mothers" of all red blood cells, white blood cells, and platelets. Once modified and reinserted, they'll produce healthy cells for life!

## ? QUESTION 1

Where do you harvest Sofia's hematopoietic stem cells from?







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- A)  From the brain<sup>17</sup>
- B)  From the bone marrow
- C)  From the liver
- D)  From the lungs

[Answer input]

---

 **FEEDBACK (if correct answer - B)**

**Exactly, Doctor Alex!**

Hematopoietic stem cells are found in the **bone marrow**, especially in flat bones like the pelvis (iliac crest). The harvest is performed with a special needle under anesthesia.

These cells are incredible: they can self-renew and differentiate into all types of blood cells!


 **Scientific data:**

- An adult produces about **200 billion** red blood cells every day
- In bone marrow there are about **0.01-0.1%** stem cells
- The treatment requires millions of cells, which are multiplied in the laboratory

 **Progress: 1/4 phases completed**

[BUTTON: PROCEED TO PHASE 2 →]

---

 **FEEDBACK (if wrong answer)**

**Not quite!**

Hematopoietic stem cells are found in the **bone marrow** (answer B), particularly in flat bones like the pelvis.

The brain, liver, and lungs have other types of cells, but not the ones that produce blood!





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 **Hint:** think about where the body continuously "manufactures" new blood cells...

 **Progress:** 1/4 phases completed

[BUTTON: PROCEED TO PHASE 2 →]

## **PHASE 2: Identifying the genetic target**

[Image: DNA double helix or BCL11A gene]

Great work! Sofia's cells are now in culture in the laboratory. It's time to understand exactly what to modify.

In her DNA there's a mutation in the gene that produces adult hemoglobin. But there's a clever alternative...

### **QUESTION 2**

[Show diagram: BCL11A gene active → blocks fetal hemoglobin]

**TRUE or FALSE?**

"In thalassemia, we can deactivate the BCL11A gene with CRISPR. This allows the body to continue producing fetal hemoglobin (HbF), which works perfectly even in adults."

- TRUE
- FALSE

[Answer input]

 **FEEDBACK (if TRUE - correct)**

**Exactly!** You've understood the ingenious strategy behind this treatment.

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When we're in the womb we use **fetal hemoglobin** (HbF), which carries oxygen perfectly. After birth, the **BCL11A** gene "turns it off" and we activate adult hemoglobin (HbA).

But if adult hemoglobin is defective (like in Sofia), we can:

1. Use CRISPR to **deactivate BCL11A**
2. **Restart** fetal hemoglobin production
3. Result: functional hemoglobin for life!

 **Curious fact:** Some populations (e.g., in Saudi Arabia) naturally have less active BCL11A. They live perfectly well with fetal hemoglobin even as adults and are protected from malaria!

 **Progress: 2/4 phases completed**

## **PHASE 3: CRISPR-Cas9 editing**

[Image: CRISPR system cutting DNA]





The crucial moment has arrived! You need to program the CRISPR-Cas9 system to modify the BCL11A gene in Sofia's cells with surgical precision.

### **QUESTION 3**

**Match each CRISPR component to its correct role:**

Drag and connect:

**COMPONENTS:**

1.  Guide RNA (gRNA)
2.  Cas9 protein
3.  Target sequence (BCL11A)
4.  Cellular repair system

**ROLES:** A) The precise point of DNA to modify - DNA target  
B) The "molecular scissors" that cut the DNA - Molecular scissors  
C) The "GPS" that brings Cas9 to the right spot - Target guide



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D) The mechanism that closes the cut, deactivating the gene - DNA repair

[Drag & drop matching area or multiple selection]

✓ **FEEDBACK (if correct: 1-C, 2-B, 3-A, 4-D)**

Perfect, Doctor Alex! You've understood the CRISPR mechanism perfectly!



**How CRISPR-Cas9 works:**

**1. Guide RNA (gRNA) = the GPS** 🗺️

- Contains a 20-nucleotide sequence complementary to the BCL11A gene
- Guides the system exactly to the right point in the DNA

**2. Cas9 protein = the scissors** ✂️

- Binds to the guide RNA
- Cuts both DNA strands at the target point

**3. Target sequence = the objective** 🎯

- The exact point of the BCL11A gene to deactivate
- Must be unique in the genome to avoid unwanted cuts

**4. Cellular repair = the seal** 🔧

- The cell tries to "repair" the cut
- But introduces small errors that deactivate the BCL11A gene
- Result: no more blocking of fetal hemoglobin!



**CRISPR precision:**

- Accuracy: ~99.9% on the correct target
- Editing time: 24-48 hours in culture
- Successfully modified cells: 80-90%


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 **Did you know?** Jennifer Doudna and Emmanuelle Charpentier won the Nobel Prize in Chemistry in 2020 for discovering CRISPR-Cas9!




 **Progress: 3/4 phases completed**

[BUTTON: FINAL PHASE →]

## **PHASE 4: Returning the cells to Sofia**

[Image: cell infusion or patient in hospital]





Sofia's cells have been successfully modified! In the laboratory you've verified that:

-  The BCL11A gene is deactivated
-  The cells produce fetal hemoglobin
-  There are no unwanted modifications in other parts of the DNA

Now it's time to reinfuse these modified cells into Sofia's body so they can do their work for life.

### **QUESTION 4**

**Before reinfusing the modified cells into Sofia, what treatment must she receive?**

- A)  Nothing, the cells are reinfused immediately
- B)  Chemotherapy to eliminate old stem cells
- C)  Wait 10 years to see if they work in the laboratory
- D)  Freeze the cells for future use

[Answer input]

 **FEEDBACK (if correct answer - B)**

**Exactly! Well done, Doctor Alex!**

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Before transplant, Sofia receives **conditioning chemotherapy** (usually busulfan). This treatment:

1. **Eliminates** old stem cells from the bone marrow
2. **Makes space** for the new CRISPR-modified cells
3. **Allows** modified cells to engraft and multiply



### Treatment timeline:

**Week 0:** Stem cell harvest

**Weeks 1-4:** CRISPR editing in laboratory

**Week 5:** Conditioning chemotherapy

**Week 6:** Reinfusion of modified cells (like a transfusion)

**Weeks 6-12:** Cells engraft in bone marrow

**Months 3-6:** Start of healthy red blood cell production

**After 6 months:** Sofia no longer needs transfusions! 🎉



### Real clinical results:

- Patients treated: over 100 worldwide (2024)
- Success rate: ~95%
- Duration of effect: permanent (stem cells live for life)
- Main side effects: related to chemo, not CRISPR



## MISSION COMPLETED!

If video

-

If audio

-

If 3D model

The formats needed are: .obj, .stl.

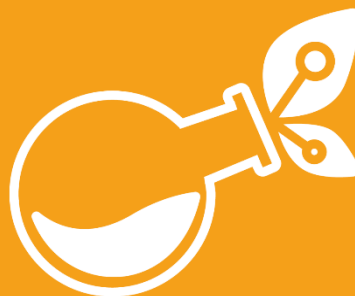
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