STEP INSIDE THE CEL



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STEP INSIDE THE CELL

A practical guide for an interactive primary school activity on cell biology synthetic biology and responsible laboratory practice

AUDIENCE	Sixth-grade primary school students, typically 11-12 years old.
FORMAT	Small teams rotating through six stations, with two teams competing at each station.
DURATION	Approximately 75-90 minutes, including feedback and recognition.
CORE PRINCIPLE	Scientific responsibility should develop alongside curiosity from the beginning.

Guide purpose: This guide supports iGEM teams, educators and science communication groups in recreating an age-appropriate journey through the cell. Students work in small teams and rotate through six interactive stations covering cell structures, synthetic biology and laboratory safety. At each station, two teams begin the same task simultaneously, and the first team to complete it correctly wins the round. This simple competitive element keeps the activity engaging without shifting attention away from learning. The activity uses only classroom-safe materials and is not a substitute for formal laboratory training.

1. Learning and Safety Objectives

- Introduce the nucleus, DNA, mitochondria, ribosomes and the cell membrane through accessible activities.
- Show that biological systems depend on ordered information, specialised structures and coordinated functions.
- Introduce synthetic biology as the purposeful design or modification of biological systems to address a need.
- Encourage students to make choices, explain their reasoning and reconsider an answer when new evidence is provided.
- Connect scientific knowledge with preparation, protective equipment, careful behaviour and shared responsibility.
- Create an inclusive environment in which curiosity, questions and mistakes are treated as part of learning.

2. Prepare Responsibly

Coordinate with the school

- Confirm the class size, available time, room layout, accessibility needs and number of accompanying teachers.
- Ask the school about accessibility needs, material sensitivities, food allergies and dietary requirements before finalising the materials and closing treats.
- Divide students into small teams and plan a route that places two teams at every station simultaneously.
- Assign at least one trained facilitator to each station and agree on a shared explanation of key terms.
- Prepare a simple score sheet and explain that the first team to complete each station task correctly wins the round.
- Keep the activities conceptual. Do not use biological samples, cultures, chemicals, sharps or experimental procedures.

Suggested materials

Station	Core materials	Preparation
Nucleus and DNA	Coloured paper cards labelled A, T, G and C	Prepare enough bases for students to build complementary pairs.
Mitochondria	Small soft balls and a target bin	Place the bin at a safe distance and clear the throwing area.
Ribosomes and proteins	Assorted building blocks and a target protein model	Prepare one clear model for students to reproduce.
Cell membrane	Wearable substance and particle cards	Label cards as water, oxygen, virus and other selected examples.
Synthetic biology	Two card sets: challenge or condition cards and matching gene or biological trait cards	Prepare clear pairs, such as an organism exposed to high temperatures and a gene associated with heat resistance.
Laboratory safety	Images of laboratory behaviours	Include examples containing mistakes for students to identify.

Scoring recognition and closing materials

- A simple score sheet for recording which team completes each station task correctly first.
- Certificates and medals for every child, recognising participation rather than only the final ranking.
- A final tally for adding the points won across the stations and identifying the overall winning team.
- If treats are offered, obtain school approval, check allergies and dietary requirements, and distribute them only after the activities.

3. Facilitation Principles

1. **Use age-appropriate language.** Introduce one new term at a time and connect it to a visible object or action.
2. **Ask before explaining.** Let students predict, sort or choose first, then discuss the scientific reasoning.
3. **Make uncertainty safe.** Treat an incorrect choice as an opportunity to examine evidence, not as a failure.
4. **Preserve scientific accuracy.** Use simple models while clearly explaining that models represent only part of a more complex system.
5. **Support inclusive participation.** Offer verbal, visual and hands-on ways to contribute, and allow students to observe before joining.
6. **Keep competition constructive.** Start both teams together, apply the same rules and confirm that the task is correct before declaring the winner of the round.
7. **Model responsible conduct.** Facilitators should demonstrate calm movement, careful material handling and respect for shared spaces.

4. Activity Flow

Part A Introduction and Grouping

Introduce the classroom as the inside of a cell and explain that the students will take the role of young biologists and synthetic biologists. Present the six stations, divide the class into small teams and explain the rotation, timing and scoring rules. Clarify that each activity is a simplified model designed to help them understand biological relationships rather than memorise every detail.

Part B The Station Journey

Arrange the rotation so that two teams work at each station simultaneously for 8-10 minutes. At every stop, the facilitator explains the task and starts both teams at the same time. The first team to complete the task correctly wins the round and receives the corresponding point. Before the teams rotate, the facilitator explains the scientific reasoning and closes with one clear takeaway.

Station 1 The Nucleus and DNA

Learning goal: Recognise DNA as an information-carrying molecule and apply complementary base pairing.

Suggested materials: Coloured paper cards labelled A, T, G and C.

Activity: Students select the labelled cards and construct complementary DNA pairs by matching A with T and G with C. The facilitator checks the completed arrangement with the group and explains that DNA carries biological information through an ordered sequence of bases.

Guiding questions: Which base pairs with A? Which base pairs with G? What rule helped you complete the second strand?

Facilitator note: Keep the model conceptual. Do not introduce real sequences or experimental instructions.

Station 2 Mitochondria and the Energy Target

Learning goal: Connect mitochondria with the production of energy in a form that cells can use.

Suggested materials: Small soft balls representing energy points and one target bin.

Activity: Students take turns aiming at the balls at the bin. Every successful throw adds energy to the cell, and the group tries to collect as much as possible. The facilitator connects the game to the role of mitochondria in converting energy from nutrients into a usable form for cellular processes.

Guiding questions: Why does the cell need energy? Which cellular activities might slow down if less usable energy were available?

Facilitator note: Use only soft objects, keep the throwing area clear and set an age-appropriate distance. Explain that the game represents the cell collecting usable energy: it is not a literal model of how mitochondria function.

Station 3 Ribosomes and Protein Building

Learning goal: Understand that ribosomes assemble amino acids into proteins and that a protein's structure is important for its function.

Suggested materials: Assorted building blocks representing the components of a protein and a clear model of the target protein structure.

Activity: Students use the available blocks to reproduce the target protein model as accurately as possible. The facilitator explains that ribosomes assemble amino acids into proteins and uses the model to show why the correct components and arrangement matter.

Guiding questions: Which pieces do you need? How will you arrange them to match the target? Why can a protein's structure affect what it does?

Facilitator note: Clarify that the blocks represent the components of the protein being produced, not proteins that form the ribosome itself. Use pieces appropriate to the students' age.

Station 4 The Selective Cell Membrane

Learning goal: Understand that the cell membrane selectively controls what enters and leaves the cell.

Suggested materials: Wearable cards labelled with substances or particles such as water, oxygen and a virus.

Activity: Students randomly select and wear a card. Two or three students act as membrane guards and decide whether each cardholder should enter the cell. After every decision, the facilitator discusses the example and explains that different substances and particles cross, or interact with, the membrane in different ways.

Guiding questions: Who did the guards allow to pass, and why? Does water enter in the same way as oxygen? How might a virus gain access to a cell?

Facilitator note: Avoid a simple good-versus-bad classification. Oxygen crosses directly, much water moves through channels, and viruses may exploit cell receptors. Emphasise that this is a simplified model.

Station 5 Introducing Synthetic Biology

Learning goal: Understand that a specific challenge can be connected with a gene or biological trait that may help an organism respond to it.

Suggested materials: Two card sets. The first contains scenarios describing a challenge or environmental condition. The second contains genes or biological traits that could provide a relevant response.

Activity: Mix the two sets and place the cards where both teams can see them. Students match each scenario card with the gene or biological trait card that best responds to it. For example, a card describing an organism exposed to high temperatures is paired with a card describing a gene associated with heat resistance. After reviewing the correct pairs, the facilitator explains that synthetic biology can use biological functions to address defined challenges, while every proposed application must also be evaluated for safety and possible unintended effects.

Guiding questions: Why do these cards belong together? How could this trait help under the stated condition? What should be considered before such an idea is applied?

Facilitator note: Keep all examples fictional and non-procedural. Do not provide organism modification steps, DNA sequences or instructions for constructing biological systems.

Station 6 Find the Mistake in the Laboratory

Learning goal: Identify safe and unsafe behaviors and explain the purpose behind laboratory rules.

Suggested materials: A set of images showing laboratory scenes with unsafe behaviours.

Activity: Students examine each image and identify behaviors that should be corrected, such as eating in the laboratory or working without appropriate protective equipment. For every mistake, they explain who or what could be affected and suggest a safer alternative.

Guiding questions: What is wrong in this image? Who could be affected? What should the person do differently? Why does this rule exist?

Facilitator note: Use clear, age-appropriate images and neutral language. Emphasise prevention, preparation and shared responsibility rather than fear.

Part C Results Recognition and Feedback

Bring all teams together and add the points won across the six stations. Announce the team with the most points as the overall winner, then recognise every participant with a medal and a certificate. In the activity delivered by our team, chocolates were also offered as part of the closing celebration. Finish by distributing the feedback questionnaire and inviting students to reflect on what they learned, which activity they enjoyed and what could be improved.

5. Suggested Timing

Stage	Time	Purpose
Introduction and grouping	10 min	Present the stations, teams, rotation and scoring rules.
Six station rotations	48-60 min	Run two teams at each station for approximately 8-10 minutes.
Results and recognition	10-15 min	Total the scores, announce the winner and recognise every participant.
Feedback questionnaire	5 min	Collect brief student feedback on learning and experience.

6. Closing and Evaluation

The activity delivered by our team concluded with a feedback questionnaire. Teams recreating it can use a brief, anonymous form with clear, age-appropriate response options. Teachers may also provide observations on participation, clarity and pacing. Record missing or unclear answers rather than inferring them, and use the results to improve future sessions.

Suggested questionnaire items for replication

- I can name one structure inside a cell and explain what it does.
- I understand why the cell membrane must be selective.
- I can identify at least two safe behaviors in a laboratory.
- One question I still have is...

7. Adaptation and Accessibility

- For a shorter session, combine the nucleus with the ribosome station and keep the safety station as the final step.
- For larger groups, duplicate high-demand stations instead of increasing group size.
- Use large-print cards, strong colour contrast and symbols alongside text.
- Read all instructions aloud and allow students to answer by speaking, pointing, arranging cards or writing.
- Avoid relying on colour alone when distinguishing DNA bases or activity categories.
- Offer an observer, timekeeper or card-organiser role to students who prefer less movement or speaking.

8. Contribution to Safety and Security

Step Inside the Cell places safety within the same learning sequence as cell biology and synthetic biology. Students first explore how living systems work, then make choices about how biological knowledge might be applied, and finally examine the behaviours required in a laboratory environment. This progression helps them understand that responsibility is not an extra rule added after discovery. It is part of scientific thinking from the beginning.

The activity contributes to a broader culture of Safety and Security by explaining the purpose behind preparation, protective equipment, careful conduct and shared oversight. It does not replace formal safety education or laboratory training. Instead, it provides an early foundation for scientific judgement, informed choices and responsible engagement with biology.