MiniGEM Kit: Mentor Guide and Judging Rubric

Context and purpose

MiniGEM is a paper-based version of an iGEM project: in small groups, pre-university students pick a real problem, design a synthetic biology solution, think through who it affects and how to keep it safe, and defend it at a poster session. No lab is needed, because this is faithful to how a real iGEM project starts: before touching a pipette, a team spends weeks defining the problem, the design and how they'd validate it.

Our proposal as an iGEM team is to have each group experience the process of ideating and designing a synthetic biology project the way an iGEM team would, with a real problem, a system design, human practices, safety and a plan for how they'd check it works and close with a poster session where we act as judges, evaluating the final proposal.

We designed and ran it as mentors at the Barcelona International Youth Science Challenge (BIYSC), *Synthetic Biology: Reprogramming Life to Shape the Future*, from 6 to 16 July 2026, alongside the programme's own lab track.

This kit serves two purposes:

1. An operational guide for us as mentors during the program.
2. A template other iGEM teams can adapt for their own youth outreach program.

Information of our version:

	Detail
Audience	Pre-university students (about 15–18), no synthetic biology background needed
Format	1 introduction + 3 mentoring sessions + poster session + reflection
Spread	Over 1–2 weeks, with tasks between sessions
Groups	2-3 students each, 1 or 2 mentors per group
Mentors	University students or iGEM team members
Materials	Printed project sheets, poster paper or a poster template, internet access for research

	Detail
Output	One conceptual project per group, presented as a poster and a 5-minute pitch
Cost	Printing and poster materials only

Philosophy of the miniGEM

- The project is **100% conceptual**. What gets evaluated is the reasoning and the design of each project.
- **Design–Build–Validate–Learn cycle**. In this case, the Build is conceptual and we replace the real Test phase with a proposed validation phase: "how would you check this works, if you had the lab and the time?"
- The **mentors ask** and help during the reasoning process, but they **don't hand over the answer directly**, they let the students investigate in the same way they would do in a real iGEM team.

Learning objectives

Skill	Basic objective	Advanced objective	Observable evidence
Scientific literacy	Distinguish observation, hypothesis, and conclusion within their own project.	Provide constructive feed-back to another team project to adapt their projects based on peer-review.	They explain it without confusing terms, and they formulate a relevant critical question for another team.
Experimental design	Identify the variables and controls of a proposed experiment.	Propose and justify a change to their design (new condition, additional replicate, etc.)	They identify the control and the variables correctly and defend why their change improves the design.

Skill	Basic objective	Advanced objective	Observable evidence
Data analysis	Read and interpret graphs.	Use that evidence to improve their own project	They explain what the graph shows and how it changed their design
Responsible design	Name who the project affects and one biosafety risk	Change the design because of an ethical, social or safety consideration	The consideration appears in the design itself, not only at the end of the poster
Communication	Explain the project in their own words to a non-expert in less than 2 minutes.	Answer unexpected questions and recognize the project's limitations.	Clear explanation without the use of jargon and handle an unrehearsed question without freezing.
Teamwork	Communicate within the group and deliver on time.	Notice when a teammate needs help and offer it.	Both students are able to defend equally their work.

Mentor's role

What we DO	What we DON'T do
Ask open questions that push groups to justify design decisions	Giving the "correct" answer directly
Share how a real iGEM team would approach the design phase	Impose our own project design
Ask them to reason through how they'd validate their idea	Suggesting results the group does not have
Give specific, actionable feedback on the proposal	Evaluate with vague judgments ("this is good" / "this is wrong")
Help them model the proposal taking into account both safety and ethics from the very beginning	Leaving biosafety for the last slide

What we DO	What we DON'T do
Note what we learn from the students' ideas	Treat the sessions as one-way teaching

Before each session, every mentor answers three questions:

1. Which part of the design is each group stuck on, or has left underdeveloped?
2. Which 2–3 guiding questions will move them forward today?
3. Which task can they do on their own before the next session?

After each session, every mentor fills in the mentor log

Besides tracking each group, it records one thing the mentor learned from the students. These notes show what the exchange gave back to the team, and they are the evidence of mutual learning to report afterwards.

Programme

Step	Goal	Group leaves with
0. Introduction	Understand what iGEM is and how an idea becomes a project	A first list of problems they care about
1. Design	Find a real problem and sketch a biological solution	A problem, a user and a first sketch on the project sheet
2. In-depth design and validation	Refine the mechanism and plan how to check it works	A validation plan and a list of open questions
3. Final design and communication	Turn the design into a clear, honest story	A poster draft and peer feedback from another group
4. Poster session	Defend the project before judges and peers	Judges' scores and feedback
5. Reflection	Look back on what they learned and what changed	A completed survey

0. Introduction

Explain what iGEM is, what are the main goals of an iGEM team/what an iGEM project should be for and what is the process an iGEM team follows to develop an idea into a full fledged project. Then walk through your own team's project as a live example: show the original idea,

the ideas you rejected and why and let students vote at each decision point to give them the opportunity to experience the development of that idea into a proper project.

1. Design

Goal: get the group to find a **real problem** and a first sketch of a biological solution.

- What real-world problem would you like to solve with synthetic biology?
- Who does this problem affect? What would they need to know, or trust, before using your solution?
- Broadly, what kind of biological system could address it: a sensor, a circuit, an engineered organism?

Possible autonomous task: have them research a similar real-world case (even one from another iGEM team) before session 2.

2. In-depth design and proposed validation

Goal: refine the design and reason through how it would be checked, without needing to execute it.

- Why this mechanism and not another? What would the biological parts need to do for it to work?
- If you had the lab and the time, what experiment would you run first?
- What result would you expect if it worked? And if it didn't?
- What could go wrong outside the lab, and how would you prevent it?

Possible autonomous task: have them leave with a 2–3 step validation plan and a short list of "things we still can't explain" to resolve before session 3.

3. Final design and communication

Goal: turn the design into a clear, honest story, and rehearse the pitch.

- If you could say only three things about your project, what would they be?
- Why does it matter? Explain past the mechanism, into the impact.
- Which question are you most afraid of? Let's practise the answer.
- What would you do differently with more time and resources?

Before the session ends, each group swaps its poster draft with another group and gives feedback using the poster feedback form. Students practise asking the critical questions a judge would ask to receive feedback from their peers.

4. Poster session

Each group presents its poster in a 5-minute pitch, followed by questions from the judges (the mentors of other groups) and from other groups. Judges score each project with the rubric in

this kit and give every group their final sum of points at the end of the session. We awarded two prizes: **Best Poster** and **Overall Best Project**.

5. Reflection

Close the programme out of competition mode. In a short circle, ask:

- What surprised you about how a scientific project is built?
- How did your project change from your first idea, and why?
- Has your view of synthetic biology changed? How?
- Would you take part in iGEM, or something like it, in the future?

Then students fill in the survey (see Evaluation).

Worksheets

1. Project sheet (one per group, opened in session 1 and updated every session)

Field	Group's answer
Group name	
Real-world problem the project responds to	
Who it affects, and who would use it	
Proposed biological system (mechanism, parts, organism)	
Why this design and not another?	
Proposed validation plan	
Biosafety risks and how they would reduce them	
Ethical or social question they considered and how it changed the design	
A question we still can't answer	

Mentor log (one per group, filled in after each session)

Field	Notes
Session (1 / 2 / 3) and group	

Field	Notes
Part of the design worked on today	
Key decision the group made, and why	
Where they are stuck	
Task they take away until the next session	
One question left open for next time	
Something I learned from the group today	

Poster feedback form (used by peers and mentors in the pre-poster session)

Question	Answer
Is the problem clear within 10 seconds of reading?	Yes / No
Is the design clearly justified?	Yes / No
Is the validation plan specific and reasonable?	Yes / No
Are safety and ethics part of the design?	Yes / No
One question a judge would ask	
The most useful comment I can give today	

Judging rubric

Judges score each criterion from 1 to 4; the rubric rewards reasoning, not results, so a group with no data can still reach the top score. Share it with students in session 2 so they know what judges look for.

Criteria	Beginner (1)	Developing (2)	Solid (3)	Excellent (4)
Design and rationale	No recognizable hypothesis or structured design. No explanation of	Proposes a biological design, but the rationale and hypothesis are	The design and hypothesis are coherently justified and address the stated problem.	The design is robust and justified. Explanation of why they ruled

Criteria	Beginner (1)	Developing (2)	Solid (3)	Excellent (4)
	why the option was chosen.	generic or superficial.		out alternative options.
Scientific feasibility	The proposed mechanism is not biologically feasible or its functionality is unclear.	The mechanism is biologically feasible, but molecular steps or interactions remain unclear.	The mechanism is feasible and molecular steps/ interactions are clear.	The mechanism is rigorous and the group actively anticipates potential limitations.
Validation plan	No mention of how they would experimentally check or verify whether the design actually works.	A vague/generic idea of an experiment, lacking specific assays or methodologies.	Concrete, reasonable experiments/assays are proposed to validate the design.	A complete plan. State the expected results if the design works versus if it fails.
Human practices and real-world context	No mention of who is affected or how it would be used	A generic user or industry, without reflection	A specific user or stakeholder, with a relevant ethical or social consideration	That reflection changes the design, not only the conclusion
Biosafety	Risks not addressed	Mentioned generically	Specific risks of their own design identified (toxicity, horizontal gene transfer)	Specific risks with realistic mitigations (a kill switch, a containment strategy)
Teamwork	One person controls the project and there's uneven participation	Roles defined but rigid	Clear roles and visible collaboration	The group supports each other and shares the pitch and questions evenly
Communication (poster and pitch)	The poster is overloaded or disorganised and	The poster is clear but dense and the pitch is	Visually clear poster, fluent pitch within time and natural	A clear story in under 5 minutes that addresses the project's

Criteria	Beginner (1)	Developing (2)	Solid (3)	Excellent (4)
	the pitch confusing	memorised or unevenly shared	explanation of the conceptual design	limits with confidence, without sounding like an excuse for having no results

Best Poster can go to the highest Communication score, while **Overall Best Project** to the highest total. Give every group, not only the winners, feedback on its strongest and weakest criteria.

Possible adaptations

We ran MiniGEM in a selective summer programme with motivated students and a lab track alongside, but we are aware that this doesn't happen every day, so here are some ideas of what could be changed to adapt this activity to other opportunities or moments:

Situation	Change
A regular school class, not a selected group	Offer multiple problems to choose from in session 1, instead of a blank page, or give each group one past iGEM project as a model.
Only one day	Introduction, design and validation as one 3-hour workshop, then a short digital poster round in the afternoon. This organisation skips the tasks proposed to be done between sessions because it all happens the same day.
Few mentors	One mentor per 3 groups with peer feedback rounds replacing part of the mentoring.
Younger students (12–14)	Drop the molecular feasibility criteria and focus on problem, user, safety and communication, so it's more friendly for the level of knowledge of this type of participants.

Situation	Change
Online	Shared slides instead of posters, breakout rooms for mentoring and pitches by video call.
Mixed languages	Let groups write the poster in their own language and pitch in the shared one.
No lab track alongside	Add one short hands-on demonstration (for example, doing a colony PCR of the bacteria you are working with in your own project) so the biology feels real.

Evaluation

Use three sources together to evaluate your own activity: the judges' rubric scores (what students achieved), the mentor logs (how they got there and what mentors learned), and this short student survey (how they experienced it).

Student survey:

1. How useful were the mentors? (1 = not useful, 5 = very useful)
2. Which part of your project did the mentors help you most with? (problem / design / validation / safety and ethics / communication)
3. Before MiniGEM, how well could you explain what synthetic biology is? Now? (1–5 each)
4. Would you consider taking part in iGEM or a similar project? (yes / maybe / no)
5. One thing you would change about MiniGEM.