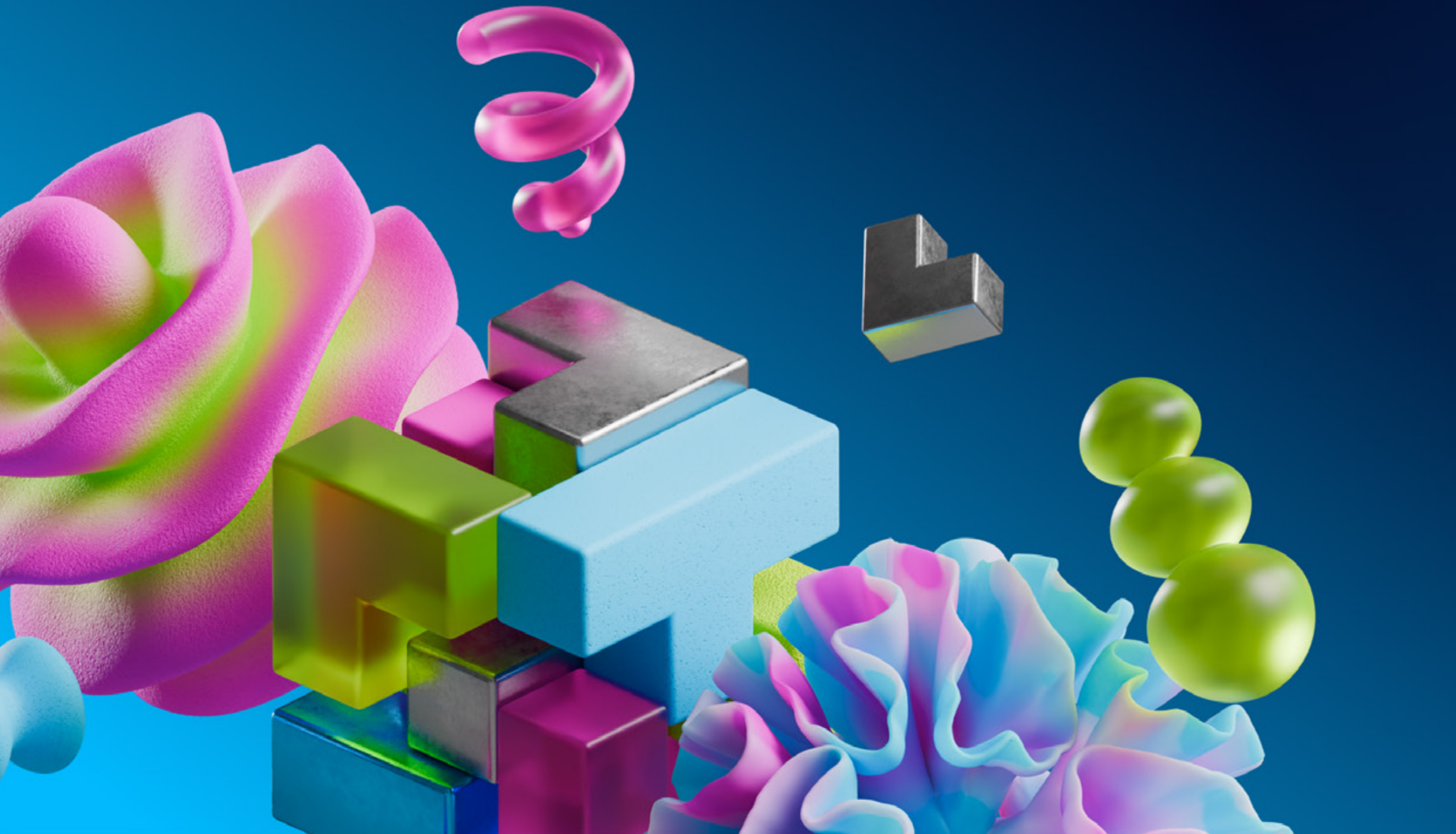
iGEM 2025

Judge Handbook

28–31 October, 2025
Paris Convention Centre



How to Use this Handbook

We have written this Handbook to help new judges get up to speed, and to help experienced judges learn what has changed since they were last involved. This book describes everything anyone would need to know about judging. Your personal experience and judging assignment may not require that you read the entire book. We suggest the following approach.

For New Judges:

1. First read: Quick Start Guide to iGEM Judging (page 11). This will give you a quick overview of the whole judging process.
2. Read Chapter 1 (page 6). This chapter goes over the most important parts of iGEM projects.
3. Read Chapter 2 (page 30). This chapter gives examples of excellence in iGEM projects.
4. Read Chapter 3 (page 40). This chapter describes the Medal Criteria.
5. Read parts of Chapters 4 and 5 after you get your assignment. These chapters detail the purpose of the prizes and provide examples of excellent work specific to each prize. Read the sections that apply to the teams you are judging.

For Veteran Judges:

1. Read Chapter 1 (page 6). Look for changes in 2025, for judging in General. Throughout this handbook, changes for the current season are marked with icons to help you find them; look for any material that is either New (NEW) or Updated (UPDATED).
2. Read Chapter 3 (page 40). Look for changes in 2025, to Medal Criteria.
3. Read parts of Chapters 4 and 5 after you get your assignment. These chapters detail the purpose of the prizes and provide examples of excellent work specific to each prize. Read the sections that apply to the teams you are judging.

If you still have questions, please email judging@igem.org with “Judging Handbook Questions” in the subject line.

Thank you for volunteering to judge! From the Judging Committee, we hope you enjoy iGEM this year!

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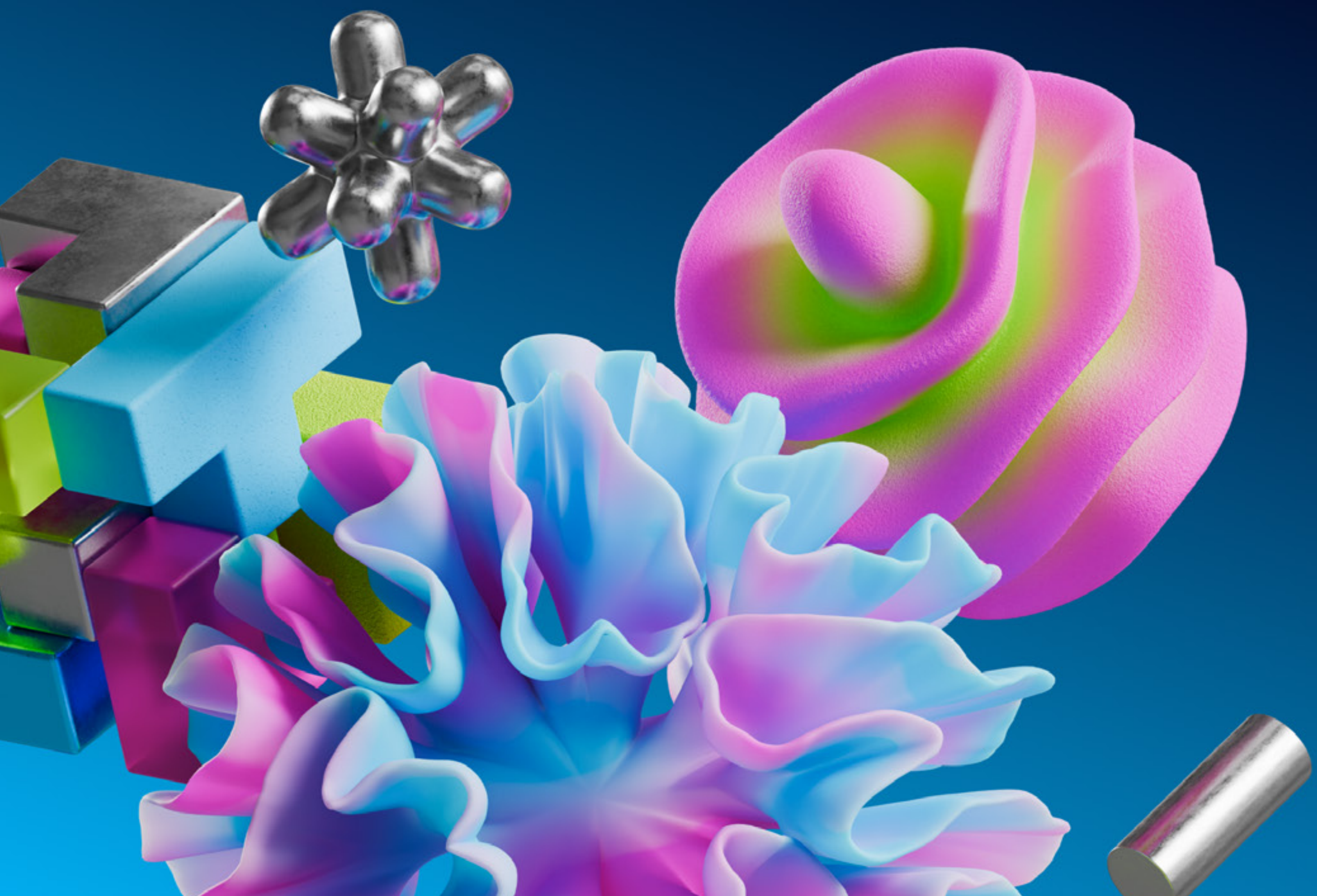
CHAPTER 1

Introduction to Judging



Introduction from the Judging Committee UPDATED

Welcome Judges, and all members of the iGEM community:

Judges, thank you in advance for your service to iGEM this 2025 season.

No matter how deeply steeped you are in our traditions of judging, there is new evolution every year. This Judging Handbook serves to help train new judges and update veteran judges. By being a public document, it also serves teams by “lifting the veil” on what once appeared (unintentionally) to be a mysterious and secret process. All members of the iGEM community can see the Handbook and have access to the same information as the judges.

The iGEM Competition

Pioneering and driving the expansion of synthetic biology, the global, annual iGEM Competition gives multidisciplinary student teams the incentive and tools to design, build, test and present projects aimed at tackling the world’s most pressing problems. This year (in 2025), recognizing the unique strengths and challenges of high schoolers, an independent High School Competition has been created to better fit high school needs.

Note: The judging criteria remains the same for both the High School Competition and the Collegiate Competition.

We continue to welcome team members of both the iGEM Collegiate Competition and the iGEM High School Competition to the Grand Jamboree, both in person and remotely. The iGEM Grand Jamboree remains unique in that it offers teams booths on the main floor throughout the event to share their projects in thematic Village spaces. The Village themes may evolve over time as iGEM seeks to highlight the most pressing challenges that the entire synthetic biology community is collectively working on. You will see a new Village this year: Art & Design.

While teams can interact with everyone in the Village spaces, they are especially eager to impress their judges. Teams will continue to demonstrate their hard work in their wikis, presentation videos and judging sessions. Judging remains a core activity at the Grand Jamboree and would not be possible without our exceptional panel of volunteer judges!

Your Role as a Judge

While evaluating all aspects of a team’s work, including each special prize the team is eligible for, we ask **each iGEM judge to serve as a “master generalist”**. Individual judges have valuable areas of special expertise, but we also ask that judges consider how to strengthen their perspective in the areas where they are less advanced. This Handbook is intended to be a resource for that effort. We also provide ways for judges to learn from each other’s expertise, in judge panel discussions that occur after each presentation session, on the iGEM judging Slack channels, and more informally in conversations in the Grand Jamboree judging room.

The role of an iGEM judge goes beyond simply evaluating teams. We have always sought to identify areas of excellence that can be celebrated with our specific awards. But we also ask that each judge consider how their role can be used to elevate the iGEM experience for all teams, not just those receiving awards. **Please think of yourself as a mentor to all teams**, from the teams whose achievements amaze you, to those that have struggled with the basics.

Giving feedback to each team is an essential aspect of achieving that mentoring goal. You will have many opportunities to provide your insights to teams throughout the Grand Jamboree — in your discussions during the judging sessions, in your conversations in the Village spaces, in your evaluation of the team using the judging ballot, and in the written comments you submit through the team's judging ballot. **Please do as much as you can to praise what is praiseworthy, balanced with fair constructive criticism.** The students have so much that they gain from your insights. Thank you again for being an iGEM judge.

On behalf of the iGEM Judging Committee,

Yorgo El-Moubayed, iGEM HQ
Fabio Maschi, iGEM HQ

A special thank you and appreciation to Director of Judging Emerita,
***Nancy Burgess Christen**, who led the Judging Committee*
for the 2022, 2023 and 2024 iGEM Competition seasons.

Nancy Burgess Christen
Director of Judging,
Emerita

The 2025 Judging Committee

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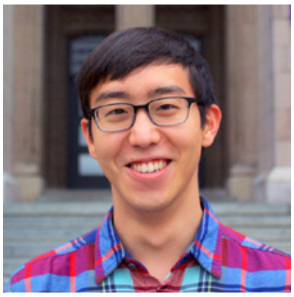

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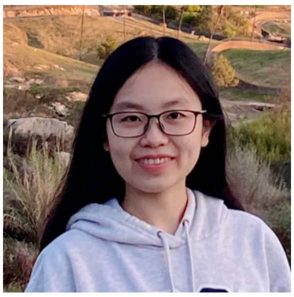


Yiyan Yu,
University of California at San Diego

Judging Code of Conduct

iGEM asks a lot of its judges, and we hold judging to a very high standard. We do this to ensure a judging process that is as fair and high-quality as possible. We also intend for each person's iGEM experience to be as positive and enriching as possible, whether that person is a judge, team member, or other member of the iGEM community. By adhering to this Code of Conduct, you are contributing to the excellence of iGEM.

1. Please be professional throughout the Grand Jamboree.
2. If you are affiliated with an iGEM team, you cannot answer questions or join in discussions about your team with other judges.
3. Every judging conversation is a confidential discussion. Judging sessions with teams are live streamed, so save confidential judge-to-judge discussion until afterward.
4. Do not inform in writing or verbally discuss your judging decisions with the teams.
5. Only judges, iGEM HQ, and invited committee members are allowed in the judging Slack.
6. When in your judging sessions, please pay close attention to the team presenting. In Zoom, identify yourself as a judge by putting the word "Judge" in your meeting name and/or turning on your video. If possible, use the iGEM Judge virtual background in Zoom.
7. Remember that all of your votes represent your opinion as an individual judge, not a consensus of the judging panel. You are not required to agree with other judges.
8. After your judging session with the teams, try to find a way to confer confidentially with your judging panel to discuss those teams. Options include moving to the judging room (if all judges are present in person), using a separate Zoom room, or using the available communication functions in Slack.
9. Do not mention specific teams on any social media platform (X/Twitter, Facebook, Instagram, etc.) until after the Awards Ceremony.
10. Keep in mind that you have an impact on these young synthetic biologists and their careers. Be supportive and instructive, while also being critical and fair.

Quick Start Guide to iGEM Judging UPDATED

Step 0: Get your judging assignment and move to Step 1 *immediately*

Don't wait until the Grand Jamboree to start judging! Most judging happens at home in the weeks before the Grand Jamboree. Starting early ensures that each team will get the best evaluation and *that each judge will have more time to enjoy the Grand Jamboree!*

Step 1: Evaluate the Wikis and Watch Presentation Videos before the Grand Jamboree

As soon as you have your judging assignment, you should watch the Project Presentation Videos (15 minutes each, page 80) and evaluate the Wikis (page 87) of your teams. As you read the wiki pages and watch the videos, please write down notes with questions and comments for each team. This will facilitate your work during the Grand Jamboree.

Step 2: Evaluate the Project and Special Prizes Sections before the Grand Jamboree

Fill out the Project and Special Prize portions of the ballot. The "Project" section of the ballot is used to determine where the team will rank in their Village and how they will stack up compared to other teams in the competition (i.e., whether they qualify as finalists). This category is one of the most important, and it should reflect the team's achievements as a whole.

Step 3: Evaluate Medal Criteria before the Grand Jamboree

Fill out the Medal Portion of the ballot. Teams are only competing with themselves to get a medal (see page 41). When evaluating a team, ask yourself if the team has convinced you that they have met each criterion individually. Check the appropriate box next to each criterion.

If you started at Step 0 and have completed Step 3, now your ballot is nearly complete before the Grand Jamboree! This means you are prepared to have great discussions with the teams and other judges. You are an awesome judge, and we are excited for your contributions at the Grand Jamboree.

Step 4: Attend the Judging Sessions during the Grand Jamboree, October 28–31

You must attend, in-person and/or over Zoom, the Judging Sessions with your assigned teams. Teams will give a 5-minute short summary of their project using any support they need (video, wiki page, slides). Then you will have 20 minutes to ask questions, have discussions and provide verbal feedback to the team. Although you may experience some communication issues if you and the students speak different native languages, do your best to distinguish between communication problems and a lack of knowledge of the project. You can ask teams to repeat an answer, and they may ask you to restate your question!

After the Q&A sessions, complete the ballots for each team before the Ballot Freeze!

Step 5: Provide Written Feedback

Teams deeply value what you think. Encourage the team with positive written feedback. Mentor the team with constructive suggestions. Quality written feedback is the most valuable thing you can do for the team! See page 13 for considerations while writing your feedback.

Step 6: Attend the Final Judge Meeting and Vote on the Winners!

Finally, the highest ranking teams as determined by the "Project", "Wiki", and "Presentation" sections of the ballot will become Finalists and will be announced on Thursday night, Paris time, October 30. The last act of being a judge at iGEM is to attend the final judging meeting on Friday, October 31. There, after each finalist team presents on the Grand Jamboree Main Stage, they will come to the Judging Room where you will have an opportunity to engage in a Q&A session with them. After each team has had an opportunity to have a Q&A with the judges, you will discuss the teams with your fellow judges, and then vote on which team will win the coveted BioBrick trophy!

Points to Consider During Your Evaluations

On Written Feedback

The most important thing you can do for your teams is to provide quality written feedback. After the Grand Jamboree, all teams receive a summary of their scores (your votes) and your written comments. Your votes and written feedback are anonymized and aggregated before they are provided to teams. Some teams will additionally win awards, but most will not. Since there are not enough awards for every team, your written feedback is the best way you can individually support and encourage all iGEM teams.

Judges are required to provide two kinds of written comments: positive feedback and constructive criticism. There are sections on the ballot to provide both kinds of feedback. Be sure to set aside time to provide useful feedback to each of your teams; you can even draft the written feedback as you evaluate your teams prior to the Grand Jamboree. Please note, **the discussions that take place during the judging sessions are not a replacement for written feedback.**

Your written comments should show the teams that you:

1. **Evaluated** all of their efforts. They should know you looked at everything they delivered for the competition.
2. **Motivated** them to push their project further. You offered suggestions for improvement and/or next steps.
3. **Congratulated** their successes and, perhaps more importantly, their resiliency in the face of setbacks or failures.

Different projects and teams will require different feedback. There is no single way to provide good written feedback. However, there are some general principles that you can use. In the following paragraphs, we provide tips and real examples of judges' feedback in quotes. Please note that these quotes have been redacted in places, to remove identifying details.

Tip 1: Make it specific to the project

Avoid vague comments without supporting details. Feedback like "Great job!" is too vague to stand on its own. Be sure to add details and tell the team *why* you think they did a great job.
Some examples:

- "It is not clear how the Michaelis-Menten enzyme kinetics model informs or relates to the design. For example,..." [Judge provided further details.]
- "Though the idea is cool, there are still a lot of questions to think about..." [Judge then listed specific questions.]
- "It appeared that you did good modeling work but I found your documentation a bit hard to follow. In particular,..." [Judge provided further details.]

Tip 2: Demonstrate your understanding of the project

Showing what you understood about the team's project demonstrates that you evaluated their data and evidence to the best of your ability.
Some examples:

- "I am absolutely delighted by the team's effort ... Awesome job! As a next step, I'd want the team to carefully assess the risks from their strategies." [Judge then offered risks and next steps on four specific aspects of their project.]
- "You have a good amount of experimental data characterizing gels you made, but only a small number of these experiments are dedicated to the [target property] of these materials. While [other property] tests are undoubtedly useful to characterize, this felt like a weak point of the project, particularly as almost none of the different variables you considered for your...designs were ever compared head-to-head in a test to see what makes the best [target property]. Additionally, much of your work under the engineering criterion reads more like routine troubleshooting than actual design-driven engineering." [Then the Judge provided advice on how to improve this part of the project.]

Tip 3: Demonstrate that you reviewed of all competition materials

The project is not just the presentation! Mentioning only the presentation in your feedback can suggest that other aspects of their work were not evaluated. As a judge, you reviewed all of their hard work; let them know!
Some examples:

- "....I think overall your wiki was a bit too basic, and you could have described more information in detail - it seems you have done more than you have written. In the parts registry, you have in-text reference numbers but no reference list. Please include it. Moving on to the implementation itself..." [Judge then asked a specific question]
- "Your video was great. I loved the paper artwork and motions. One minor suggestion would be to try to not read off a script. I really enjoyed going through your wiki. It was very easy to read and understand. Very nice job with the Q&A!..."
- "Professionally executed with commendable technical knowledge and design skills. Showcasing of how the team redefined their experimental process enabled judges to grasp the team's critical thinking abilities. Integrating solutions from experts in the field was an integral part of redefining the project. Risks were well thought out and accounted for..."

Tip 4: Be supportive and constructive

Most iGEMers are undergraduate students and, in some cases, they're high school students, and they take your comments seriously. Remember that the tone of your constructive comments can be a major influence on an iGEMer's future career choices in synthetic biology.
Some examples:

- "It was a pity that you did not have the possibility to work in the lab. However, with your approach to showcase your expected results, you coped well with the issue. I missed that you didn't include potential problems and discussed mitigations - as this is the true obstacle when you are doing research."

- "The team could benefit largely from trying to use different [target] compounds and comparing the efficiency of degradation. Also, the team could benefit even more from showing results from emulation of real-world situations. For example, the team could have made a small-scale bioreactor growing their bacteria and introduced [target compounds] into the system to show that their system could work at a larger scale than just within a very well-controlled test tube."
- "Some results in the [Proof of Concept] were difficult to understand, and I had a hard time coming to the same conclusions as you. For example,..."[Then the Judge provided a detailed example, citing a specific figure and an alternate conclusion.]

Tip 5: Write as clearly as possible

Remember that English is a second language for most iGEM teams (and judges!). For some teams, being able to view written comments in plain English and translate them back into their first language allows them to understand your feedback and learn from you.

On Engineering

Engineering Biology

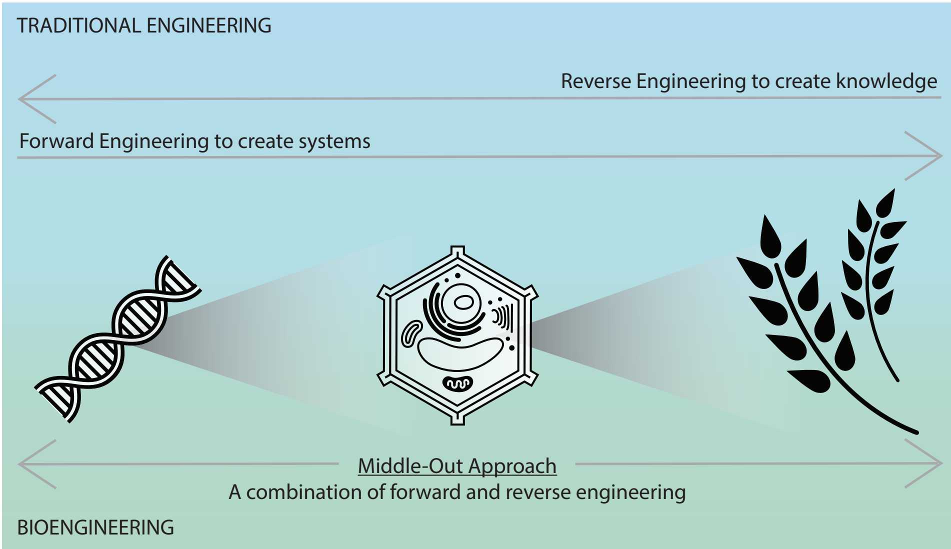
The engineering of biology has been at the heart of iGEM from the beginning: iGEM is an acronym for "international genetically *engineered* machine". Here, we outline an iGEM perspective on engineering methods for the use of team members and judges. Our goal is to celebrate engineering excellence while remembering that engineering comes in many different forms. Biological engineering is still in the process of developing its own discipline-specific tools and practices, and iGEM teams are an important part of that development.

What makes a good engineering project, and how should this be recognized? In the text below, we briefly provide some context on engineering biology. If you want to get straight to the practicalities, please go to "Excellence in iGEM" on page 30.

Engineering is the creative, rigorous application of knowledge about a system to solve problems or develop new technologies and products. Perhaps most importantly, engineering represents an unbiased lens through which problems can be viewed and solved. It is a mindset and a framework that enables systematic thought about the assumptions and approximations in a design, defining both what is known and what is unknown in order to gain a view on the expected performance of a design. In this mindset, success and failure are equally valuable since they both provide answers to the question at hand and help validate or dismiss our assumptions.

> *"Failure is central to engineering. Every single calculation that an engineer makes is a failure calculation. Successful engineering is all about understanding how things break or fail." **— Henry Petroski***

Well-established engineering fields, such as aircraft engineering, give us a good idea of how we might proceed with *forward* engineering biology (i.e., bottom-up synthetic biology). When building an aircraft, the engineering tools are so mature that computer aided design and simulation can entirely replace physical mockups and testing that used to be done before a full test aircraft was built. The first 777 was built directly from the *in silico* designs with (almost) no physical tests of sub-components, and it was tested by fueling it up and flying it. What will we be able to do with biology when we have even a fraction of this level of predictability, and how do we get there?



Unlike many established areas of engineering, we tend not to build our biological systems from scratch and there are significant gaps in our knowledge of the systems we wish to engineer. Imagine discovering the wreckage of an alien spacecraft and attempting to use extraterrestrial technology. To understand and wield this technology it would be necessary to reverse engineer it - to deconstruct the system to reveal its design and gain knowledge that we may re-apply elsewhere. This is similar to our relationship with biology. Therefore, our approach to engineering biology is neither fully “top-down” nor is it yet “bottom-up.” Instead, our approach must be “middle-out,” as Nobel laureate Sydney Brenner has thoughtfully observed.[1]

Acknowledging the necessity of our middle-out approach to engineering biology naturally leads to recognizing the importance of defining unknowns and knowns. This is core to a rigorous engineering methodology/process. Projects that excel in engineering will have demonstrated such a methodology, which is outlined below. Embracing an engineering framework will not only help iGEM teams succeed, but will accelerate the growth of the entire field of synthetic biology, which will eventually give rise to true forward engineering of biological systems.

References

[1] Brenner S, Noble D, Sejnowski T, Fields RD, Laughlin S, Berridge M, Segel L, Prank K, Dolmetsch RE. 2001. Understanding complex systems: top-down, bottom-up or middle-out? In Novartis Foundation Symp. Complexity in Biological Information Processing, vol. 239 (eds Bock G, Goode J, editors.), pp. 150–159 Chichester, UK: Wiley

Engineering Methodology - General Outline

- Identify and demonstrate understanding of the problem
- Gather data (and cite sources) and recognize unknowns and constraints
- Select applicable guiding principles and theories
- List assumptions, approximations and simplifications
- Establish quantifiable measures of success
- Show how the problem was solved
- Validate the results
- Communicate the solution

What to look for and reward in an iGEM project

Well-engineered projects can score well on multiple parts of the judging ballot, all of which are highlighted in bold in the bulleted list below. Projects should score well if they have used clear engineering practices to define and execute the project themselves, and/or they have paved the way for others by creating well-characterized and documented parts or tools for future engineering efforts.

The best engineered projects may often not be the largest. In fact, in previous years the most impressive projects have been those that don't try to take on too much, but clearly define the problem as well as criteria for success and then engineer robust, and well-characterized solutions.

Beyond whether the team achieved their goals, consider how convinced you are that the work is reproducible and is a solid foundation for future work:

- Have they used **models** to meaningfully predict the behaviour of their system or guide their experimental or design choices; or, alternatively, have they subsequently built models that characterize and explain how their system works?
- What experiments did the team do, and were the data **replicated** or built upon?
- How rigorous are their experimental designs and **measurements**?
- How well communicated are their results (**wiki/presentation**) to ensure others can build upon their work?
- Teams may have built **software** tools to help, either with the simulation of their system to design functionality, or to predict behavior.
- How much attention have the teams given to making the progress they have made reusable? For **parts**, or **part collections**, how well characterized are they? Is this clearly documented on the Registry? Would you be happy to use these parts?

Overall, consider how well the team has managed to systematically apply knowledge to create a new technology or solve a problem. And additionally, consider how much effort they have put into characterization and communication of their project, to lay solid foundations for those building off their work in future.

On Judging Parts UPDATED

The iGEM Competition began with Parts. The focus dates back to when the first class at MIT asked the question, *"Can you build simple biological systems out of interchangeable parts?"* All iGEM Parts should be cataloged in the Registry. In the Registry, teams share documentation on their design, experiments and data of each Part. The information is a fundamental aspect of the competition and a resource for the teams and the broader iGEM community. We encourage judges to hold teams to high standards by following the Rubric carefully when evaluating Parts.

Important Notice: Welcome to the New iGEM Registry!

iGEM launched the beta version of our brand-new iGEM Registry: A modern, cloud-based platform designed to support integration with external tools, partner platforms, and with an eye towards a future "federation" of registries. The classic parts.igem.org site has been retired to preserve its rich 20-year history while we build its successor. All pages remain publicly viewable and searchable, but log-ins, part submissions, and edits are from now on disabled. Most of the core part data you rely on (sequences, descriptions, and metadata) has already been copied over on our new modern Registry.

For the latest records, a streamlined search, and the features we'll be rolling out over the coming months, please visit https://registry.igem.org

Detailed instructions for how to submit or document parts are now available on https://registry.igem.org. If you have any immediate questions, please contact us at registry@igem.org

Part Documentation

All part-related documentation must be on the iGEM Registry on a Part's respective part page. If a team has not entered documentation on their part pages, they have not met part-related requirements. The exact requirements for part-related medal criteria are available on the website (https://competition.igem.org/judging/medals) and in the medals section of this book (see page 40). How Teams should document parts is described in the New Basic and Composite Part Prizes section (page 72).

Assembly compatibility

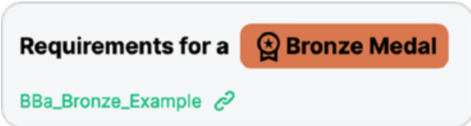
For a Part to be compatible with an assembly standard, that Part must fulfill all requirements of the standard, including the absence of any restriction sites that would interfere with that standard.

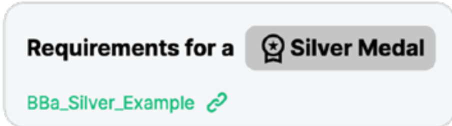
When teams submit their new parts to the Registry each year, the sequences of those parts are screened for assembly method compatibility. Parts being evaluated for medals and awards in an iGEM Competition must be compatible with either RFC 10 or iGEM Type IIS assembly (RFC 1000). The Registry supports several other assembly standards, but they are not relevant to the competition. You can read more about assembly standards on the iGEM website (https://technology.igem.org/assembly/assembly) or in the Registry (https://parts.igem.org/Help:Standards/Assembly).

Judging Parts for Different Criteria

Bronze & Silver Criteria

Where to find the part on your ballot: Parts that need to be evaluated for either Bronze or Silver criteria will be found at the top of the relevant medal section. For example, if a team uses a part to meet the Contribution criterion for the Bronze Medal, that Part will appear at the top of the Bronze medal section and not inline with that specific Bronze medal criterion. See these examples:

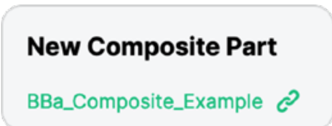




Judging Tip: Because both the Bronze and Silver medal criteria do not require Parts, it is possible that a team has submitted both (1) a Part and (2) non-part related documentation for those criteria. They will have met the criteria if you are convinced that at least one of these activities achieves it. For example, Team Example has submitted an existing Part, BBa_XYZ for Bronze criteria #3 on their judging form. Team Example also has a separate contribution (non-part related) on their Contribution page (https://2025.igem.wiki/example/contribution). Their Part BBa_XYZ has no documentation on the Registry, but you are convinced they have made a useful non-part related contribution on their Contribution page. Team Example has met the medal requirement for Contribution (https://competition.igem.org/judging/medals).

Gold Criteria and Special Prizes

Where to find the part on your ballot: Gold medal criteria are met when teams compete for three Special Prizes. Therefore, Parts submitted for Gold Medal criteria will appear at the top of their respective Special Prize section on the ballot. For example, if a team wants to use the New Composite Part Special Prize to compete for a Gold medal, that Part will be listed with Special Prize.



Judging Tip: Remember that teams do not need to use Parts to qualify for a Gold Medal (https://competition.igem.org/judging/medals). For full details about judging Parts Special Prizes, please see the relevant Special Prize sections in this handbook.

On Measurement

The Role of Measurement in iGEM Judging

Measurements are critical to communication about any scientific or engineering project. Well-reported measurements are the only way to show whether hardware is functioning correctly, whether data are reliable, and whether a result is actually important. Different DNA parts and devices have different functions, and thus different properties that are important to measure, such as the strength of a promoter, the efficacy of a termination site, or the signal amplification of a repressor-based inverter. In every case, however, there is a high value in identifying appropriate targets for measurement, collecting precise measurements, and reporting results clearly and with appropriate units. Good measurement makes for better projects, deeper results, and enables reuse building on the reported devices, systems, and protocols.

Without measurement data, it can be difficult to evaluate whether a project or sequence has been "successful." However, for many biologists some qualitative assessments appear "obvious": quantifying with a number is not second nature and may even be seen as a distraction. Complementarily, for many engineers, a lack of quantitative numbers can appear to mean that nothing has been determined. Blending these two viewpoints for working with biological systems is vital, as synthetic biology merges both biology and engineering.

Qualitative assessments can provide a good first approximation of "did something work?" Once the answer is "yes," however, it is critical that a team at least shows clear thought about how to move from qualitative to quantitative measurements. While we would like all teams to present robust, quantitative data, not all teams will have progressed their project to the point that they can present reliable numbers. It is better that a team presents and acknowledges limited, qualitative assessments than they attempt to report flawed quantitative measurements.

Good presentation of appropriate measurements should allow you to answer the following questions about a DNA part or system:

- Is the function of the part or system reproducible? *(Good example: A repressor regulating a promoter in three biological replicates with minimal quantitative variation between them.)*
- Is the functionality reliable when used as a component of other systems? *(Good example: A terminator that stops transcription of different coding sequences with the same efficacy.)*
- Does the part or system function under only specific host or environmental conditions? *(Good example: Showing function across multiple strains of E. coli and different media.)*
- How does the functionality compare to control systems or similar prior parts? *(Good example: Comparing a repressor regulating a promoter to a constitutive promoter, blank cells, and a known repressor/promoter pair for the same organism.)*
- Is the functionality of a part so strong and clear that qualitative assessments are sufficient to demonstrate function, or are precise quantitative measurements and specific statistics required? *(Good qualitative example: Morphology change of E. coli from normal to filamentous; quantitative example: Tuning a gene's expression to multiple levels in a 10-fold range.)*

Analogous questions should be answerable for hardware or other produ cts of a team's project. Even strong teams may not have clear answers to all of these questions, but the more questions that are carefully considered and the more that are clearly answered, the stronger the measurement component of a team's project.

On Human Practices UPDATED

Human Practices (HP) is the “bigger picture” part of iGEM. The Human Practices Page (https://responsibility.igem.org/human-practices) contains a wealth of information, resources and examples, including (Frequently Asked Questions) within the competition page (https://competition.igem.org/about/faq). Here are some important highlights for a judge.

Through their Human Practices efforts, teams must convince the judges that they have carefully and creatively considered whether their projects are responsible and good for the world. We expect teams to show that they have been:

Reflective, considering which values and needs they are prioritizing, and where they are compromising.

- **Reflecting on design decisions**: Teams need to iteratively reflect on design decisions throughout the project, with conscious attention towards whose needs and what values are prioritized and where compromises are/were made.
- **Exploring and reflecting on context beyond the lab**: Teams need to explore and reflect on the larger context of their projects, such as regulations, policies and markets. These reflections should inform their project decisions and how the team interacts with the public.

Responsible, communicating honestly and considering how their project could impact the world, for better or worse.

- **Incorporating diverse perspectives**: Teams need to consult and learn from diverse stakeholders, including those who might hold critical views towards the project, with two-way dialogue. In addition, teams need to demonstrate robust rationale for identifying and reaching out to those stakeholders, and show how their feedback/research was incorporated into their projects. Also, teams may act as knowledge brokers between stakeholders to facilitate the synthetic biology solution/innovation they are proposing to send out in the world.
- **Anticipating positive and negative impacts**: Teams need to critically and thoroughly anticipate both positive and negative impacts of their project. They should forecast whether the techniques/knowledge they develop could be misused–no matter how remotely–or create ethical, social, and/or legal problems. Teams should demonstrate the willingness, capabilities and skills to either alter their project or develop sufficient countermeasures to mitigate such risks.

Responsive, taking responsible actions and adjusting projects based on what they have learned from stakeholders and others they engage with, and aiming to “close the loop” between their design and the world.

- **Responding to human practices work**: Teams are expected to integrate human practices throughout the lifecycle of their project, including making great efforts in addressing the feedback from all stakeholders as well as in promoting human practices by and among team members.
- **Approaching limitations with integrity**: Teams should know the limits of their project and their own abilities, and adjust their projects accordingly. They have tried to learn from, build upon and acknowledge existing work. They are hum-

ble and honest in assessing and comparing alternatives to their approach and can demonstrate how effective and creative their solution to the "big picture" question is.

In general, we want to see the teams draw on their Human Practices work to construct evidence-based arguments in support of their technical-scientific-engineering decisions. Teams should provide a convincing rationale for why they designed their project the way they did, and should build upon and reference prior work.

Human Practices work can take many different forms. Teams have conducted environmental impact analyses, created museum exhibits, written intellectual property guides, facilitated "white hat" biosecurity investigations, and even performed street theater. They have consulted and shared their experiences with stakeholders, constituents, policymakers and the general public in their countries, as well as with international forums such as the United Nations. Nevertheless this is not an exhaustive list of activities, and teams are encouraged to think "outside the box" with their Human Practices approach. Although often an appropriate method, teams do not need to directly engage with stakeholders to successfully investigate Human Practices issues.

Human practices should be innovative and creative. The above dimensions may not cover all aspects of human practices, and there are no fixed rules for doing human practices. We are looking forward to seeing projects and human practices work going beyond present descriptions. Creative human practices work would be highly encouraged and given special consideration in awarding the integrated HP Special Prize.

We expect all teams to attempt Human Practices-related activities. It is **a silver medal requirement**, and one option to qualify for a gold medal. HP activities are evaluated as part of a team's overall project score to compete for the grand prize and individual village awards.

We expect teams to engage respectfully and responsibly with stakeholders. Teams should not "proselytize" or "market" iGEM and synthetic biology by telling the community that iGEM is great and will "save the world". They should instead establish a two-way dialogue, listen to the people and communities they consult, and seek to build the understanding of the issue with them collaboratively. See also "Important Notes of Activities Involving Humans" below.

Human Practices Criteria for Medals and the HP Special Prize

- **For the silver medal criteria,** teams should explain how they have determined that their work is responsible and good for the world, by investigating one or more "bigger picture" issues. This investigation could take the form of personal reflections, background research, and/or engagement with communities relevant to the project.
- **For the gold medal criteria,** teams must do impressive work for the Best Integrated Human Practices Special Prize (see more details on page 63). Briefly,

teams should demonstrate how their investigation of HP issues has been integrated into the purpose, design and execution of their project in a particularly meaningful and creative way. Teams must go beyond just considering "bigger picture" issues, and take concrete action in response to their Human Practices reflections, research, and/or engagement. They must show that the purpose, design and/or execution of the project evolved based on what they learned through their Human Practices activities, for example by planning a different final application for the work, updating user interfaces, using alternative wet lab methods, or proposing regulations to improve the project's impact.

- **The Best Integrated Human Practices Special Prize** will be given to the best example of integrated Human Practices based on the rubric score (see more details on page 63).

Important Notes on Activities Involving Humans

- **Teams must comply with iGEM's Safety Policies, including the human experimentation** (https://responsibility.igem.org/safety-policies/human-experimentation) **and human subjects** (https://responsibility.igem.org/safety-policies/human-subjects) **policies.** It is a team's responsibility to check with their institution and/or local authorities whether their activities (such as surveys, interviews, or other types of engagement) qualify for additional oversight, and to comply with relevant rules (especially around vulnerable populations such as patients and minors).
- **If teams are conducting surveys and interviews,** we expect teams to not only check oversight policies, but further to consult resources and experts (such as those on their institution's IRB board/ethics committee and those on the HP Committee members) to **ensure their survey designs are valid and adhere to best practices in the field.**
- When participating in HP activities, teams must ensure that basic issues such as the safety and personal privacy of participating members, including team members, are not infringed.

What about Human Practices activities that are not directly related to the project?

Through education, outreach, and public engagement, teams may cover topics that extend beyond their particular project. For example, teams may work with teachers to integrate synthetic biology into their curricula or with artists to communicate and challenge synthetic biology concepts. When these activities involve exchanges between teams and the public, but no interchange of ideas between the project and the "bigger picture", they are not considered Human Practices.

- There are special prizes, like the Education Prize and the Inclusivity Award, which recognize excellent work to establish dialogue with new communities and to engage and involve new people in synthetic biology in general.
- Some Education, Inclusivity, and Integrated Human Practices activities may be overlapping and contribute to multiple prize qualifications. However, because the goals of these activities differ, they should be documented and described clearly and distinctive from one another in respective sections in teams' wiki pages.

Human Practices Maturity Model: a tool to help understand and evaluate Human Practices work

The HP Committee is developing the Human Practices Maturity Model (https://responsibility.igem.org/human-practices/maturity-model) as a tool to help both the teams and the judges to understand and evaluate human practices work. This is exploratory and collaborative work, and we welcome your feedback. If you have any comments or feedback on this Maturity Model, please contact: humanpractices@igem.org.

On Safety UPDATED

At iGEM, we believe that identifying and managing risks from synthetic biology is everyone's responsibility. In some labs, risk assessment might be done exclusively by a PI or a lab manager, but iGEM expects all synthetic biologists to build up the skills to think critically about the safety and security of their work.

Throughout the competition, all iGEM teams are expected to carefully consider and manage risks to themselves, their colleagues, their community, and the environment.

iGEM has clearly communicated the **Safety Rules** (https://competition.igem.org/participation/rules-and-policies) and **Policies** (https://responsibility.igem.org/safety-policies/) that every team must follow. Each team has submitted a final Project Safety Form, which has been reviewed by the Safety & Security Committee. The reviewed forms are available to the public on each team's dashboard. Find the specific team at https://teams.igem.org/list. After clicking on the team name, scroll down to find the "Team Deliverables Overview" and click on "Safety Forms".

New: For 2025, High School teams are required to work within the iGEM Whitelist

https://responsibility.igem.org/guidance/white-list

This means that these teams do not have access to parts, organisms, or activities that require a Check-in Form or Animal Use Form. Practically, this means that high school teams should not be working with animals, most sporulating fungi, organisms that are BSL-2 or higher, or engaging in activities involving human samples. If you are unsure about permitted activities on the iGEM Whitelist you can email safety@igem.org for a clarification or determination.

Questions or Concerns? If you feel like any of the rules or safety policies have been violated, or if you have questions, please email us at: safety@igem.org

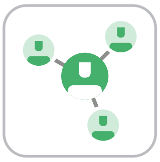
On the Responsible Conduct Committee UPDATED

iGEM has four rules of conduct: (1) uphold iGEM's values, (2) be intellectually honest, (3) treat everyone with respect; and, (4) consider cultural context. iGEM students, advisers, instructors and judges are almost always exemplary in their conduct and behavior.

However, in cases where these rules of conduct are breached, a formal process to investigate is required. Allegations of misconduct are treated very seriously and are investigated by the Responsible Conduct Committee (RCC).

Please see our **Rules and Policies** (https://competition.igem.org/participation/rules-and-policies) for more information, including hypothetical case studies and information on what happens if a team or individual violates a rule.

If you think a case of misconduct requires investigation, please contact: rcc@igem.org. You will receive a confirmation indicating whether the case will be pursued and if further action is needed. Please note that all reports are handled with strict confidentiality.



On Attribution UPDATED

We care about teams telling us what they did and where their ideas originated. Teams are required to report their attributions through a standard Attributions Form. This is so we can ensure consistency and clarity in the way that teams report who did what work. The Attributions Form details of work done by both team members and external partners. It is a competition deliverable and must be completed on time for teams to be judged in the competition.

The standard Attributions Form consists of three tables:

- **Table 1: Team Member Contributions** - Lists what each team member accomplished.
- **Table 2: External Contributions** - Lists what external parties (i.e., individuals, groups or institutions not on the current iGEM Team Roster) accomplished.
- **Table 3: Project Timeline** - Lists the start and end dates of different parts of the project.

Detailed instructions for the form are available on the competition website (https://competition.igem.org/deliverables/project-attribution).

We encourage judges to evaluate whether the Attributions Form is complete and reasonable. Is every field of the standard form, including "specific tasks", filled out? Does the information provided make sense based on what the team accomplished? Are all major aspects of the project (such as the project idea, design and execution) clearly attributed? Are there any key elements missing, or is it unclear who was responsible for essential parts of the work?

If the Attributions Form seems like it may be inaccurate, we encourage judges to seek clarification with the team. Remember, you are a mentor; **it is not up to judges to make accusations or suggest punitive measures.** If there is a specific reason to be concerned about the team's honesty in reporting, judges have the option to reach out to the Responsible Conduct Committee at rcc@igem.org.

On Villages UPDATED

iGEM Villages are specialized, topic-centered hubs where iGEMers, experts, policymakers, strategic partners and the greater synthetic biology community, come together to solve today's critical and interconnected global challenges. At the Grand Jamboree, we build Village spaces where the teams, judges, and other community members can gather and discuss projects throughout the event. Each team is assigned a booth within a Village space that they can use to represent their team project in various ways, including to show their presentation video, to demonstrate hardware, or simply to hang out. Teams choose a specific village based on the challenge that their teams are tackling, such as Diagnostics, Biomanufacturing, Foundational Advance, etc. See the competition website for more information about Villages: (https://competition.igem.org/deliverables/village-selection).

There is nothing specifically judged in the Village spaces, though a judge may certainly improve their understanding of the teams' projects there. Furthermore, this is the best place for judges to see what every iGEM team brings to the competition. If you can attend the competition in person, we hope that you will have done your judging early so you can spend some time in our Villages at the Grand Jamboree!

What Happens When I Cast a Vote? UPDATED

Judges are often curious as to how their votes affect the final outcome of the Grand Jamboree. In this section, we will provide a brief overview to explain this process. You will see that every vote matters, and that your actions and decisions as a judge have a big impact!

On the judging ballot for each team, each judge casts votes pertaining to medal achievement, various project-related categories and special prizes. Each team is assigned six judges for whom we have eliminated any known conflicts of interest. In addition, judges are generally "mixed" across various teams to ensure that a particular group of six judges can draw from a variety of judging experiences and professional backgrounds.

For each ballot category, the votes from that panel of six judges are then used to determine award eligibility and winners. *Thus, it is very important to match your vote to the rubric language in the ballot as much as possible, to ensure consistency across the judging body.*

Here is how the various prize-winners are determined:

<table>
<tr><th>Medals</th><th>Special Prizes</th></tr>
<tr><td>Majority vote for each medal criterion, to determine if met.
Ties in voting are ruled in favor of the team. For example, if three judges think a medal criterion is met and three judges do not, it is ruled that the team has met the criterion.
Teams win the highest medal for which all criteria are met.</td><td>Highest average score from the relevant Rubric category</td></tr>
<tr><th>Village Awards</th><th>Finalists</th></tr>
<tr><td>Highest score from a weighted average of these Rubric categories: Project, Presentation, and Wiki, within each Village (or a Village group for teams in the High School Competition).
There will be one Village Award given to undergraduate teams and one to overgraduate teams, on the condition that there are more than 10 teams in each of the sections within that Village.
If there are fewer than 10 teams in either the undergraduate or overgraduate section of a Village, only one Village Award will be given for the highest score of all teams in that Village.
There will be one Village Award given to teams in the High School Competition, for each Village Group (see groupings below). Each Village Group must collectively have at least 10 teams.
The Village Groups for the High School Competition are:
Group 1: Diagnostics, Infectious Diseases, Oncology, and Therapeutics;
Group 2: Climate Crisis, Conservation, and Bioremediation;
Group 3: Agriculture, Food & Nutrition, Fashion & Cosmetics, and Art & Design;
Group 4: Foundational Advance, Software & AI, Biomanufacturing, and Space.</td><td>Highest score from a weighted average of these Rubric categories: Project, Presentation and Wiki, within each section (undergraduate, and overgraduate from the Collegiate Competition, and high school from the High School Competition).
There are 3 finalists in the undergraduate section, 2 in the overgraduate section and 2 in the high school section.</td></tr>
</table>

Finally, all award decisions require a minimum number of votes and minimum vote score. For any given prize, if there are no teams with a sufficient number of judges voting on a prize, or with a sufficiently high score, no team will receive that prize. It is therefore critically important that all judges vote in all relevant ballot categories (i.e., the ones that are made visible to you). **By abstaining from voting or voting carelessly, you could render a team ineligible for one or more prizes!**

Standard Pages for Awards

To make it easier for judges to find relevant documentation, we have created pages in the wiki template for specific awards and medal criteria with static (unchangeable) URL links. We refer to these URL links as Standard Pages.

If a team wants to be evaluated for a medal or special prize, they will need to document their achievements related to this medal or special prize on these Standard Pages. For example, if a Team Example wishes to compete for the Best Plant Synthetic Biology special prize, they need to complete the (Plant Page) on: https://2025.igem.wiki/example/plant.

The judges are directed to these pages from static links within the judging ballot. Teams should put all the information needed to convince judges on the relevant award pages. Teams can add supplementary material on separate pages, as you would with supplementary data in a publication. If teams want judges to look at the supplementary material, teams may guide judges from the Standard Pages to additional pages on their wikis (but not to external sites!). As with any effective writing or communication, teams must guide the judges through their material. Judges are not required to independently seek out additional information about a team's effort for an award or prize.

What does this mean?

1. **Teams must preserve designated URLs** in order to be evaluated for the relevant awards, regardless of how they style their wikis.
2. **Content on sites external to iGEM servers should NOT be judged.** This includes any project materials that are external to the Wiki, Registry and iGEM's GitLab hub. External sites and materials are not subject to the Wiki Freeze or to the iGEM archival process. Thus, they are outside the scope of the competition. If a judge finds externally hosted content, they can contact the Judging Committee on the Judge Slack Channel, or by emailing judging@igem.org.

Regardless of how teams style their wikis, they will need to preserve designated URLs in order to be evaluated for the relevant awards.

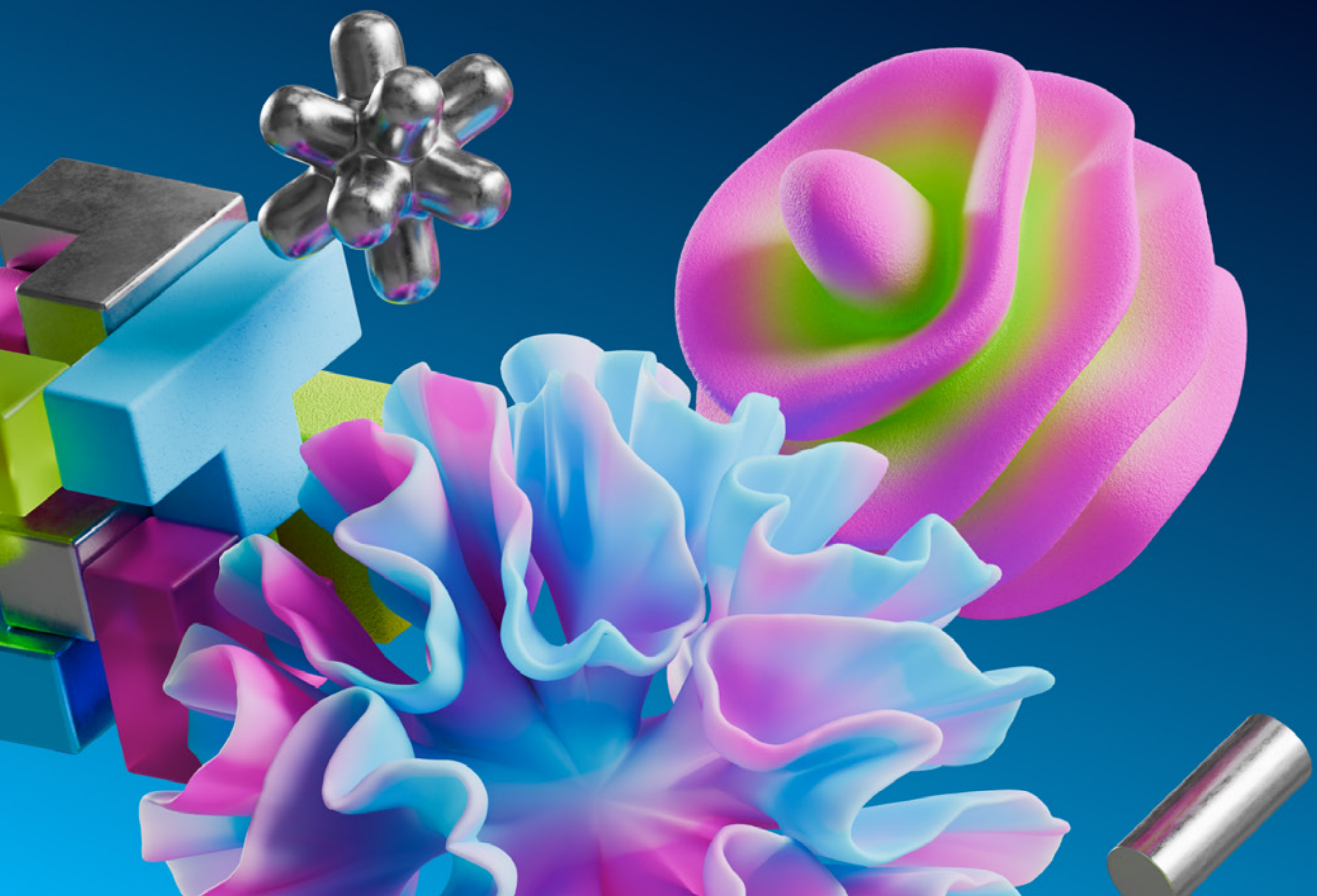
Where are the links?

Team wikis will include all of the necessary pages by default. You can refer to the list of pages for medals on page 45 and for special prizes on page 48. All content (except part pages on the Registry) should be contained in the official team name space.

For more information, please see:
https://competition.igem.org/judging/project-prizes.

CHAPTER 2

Excellence in iGEM



Finalists Case Studies UPDATED

Introduction

What are the characteristics of the very best iGEM projects? What sets them apart?

A team that will win the iGEM Competition not only presents a successful and well-communicated project, but also embodies the goals and values of the iGEM Foundation itself – advancement of synthetic biology, impact, education, accomplishment, use of standard parts, and integration of Human Practices, to name a few.

A successful iGEM project includes the following components: a wiki, a presentation and remote or in-person participation at the Grand Jamboree, and some contribution to the community (e.g., DNA parts, software, etc). Although great teams demonstrate excellence in all of these components, the very best teams go above and beyond, not only presenting a clear and powerful story, but also connecting their projects to the wider world through careful consideration of their project's consequences.

Finally, it is important to note that iGEM is designed for team members to grow and learn; projects should be motivated, researched, and carried out primarily by the students. Effective use of available resources is important and encouraged, but careful attention should be paid when the team writes the attribution of each part of their project.

These aspects of success are reflected in the "Project" section of the judging ballot, which is the main determinant for choosing finalists:

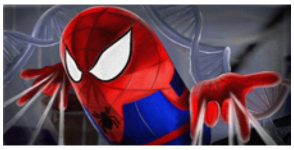
1. **How well were engineering principles used (e.g., design-build-test cycle, use of standards, modularity, etc.)?**
2. **Did the team design a project based on synthetic biology and standard components (BioBricks, software, etc.)?**
3. **Did the project work or is it likely to work?**
4. **How competent was the team, collectively, at answering judge questions?**
5. **How well did the team's data (modeled and/or experimentally measured) support their claims?**
6. **Is the project likely to have an impact?**
7. **How well did the team demonstrate that their Human Practices work influenced the design, execution, application and/or other aspects of their project?**
8. **To what extent did they convince you that their Human Practices activities helped create a project that is responsible and good for the world?**
9. **Are the project components well documented on the team's Wiki/Registry pages (parts must be documented in the Registry)?**
10. **How much of the project was initiated and led by the students?**

Excellent teams do not necessarily need to score highly in every aspect; they do create work that impresses the judges. Impressing the judges is what distinguishes winning teams from great teams. Using the rubric, judges can reward the best work according to how impressive the scale and scope of the project is, instead of according to a minimum set of criteria that teams need to meet. Judges evaluate the excellence of the work achieved in a given time, which is not limited to "tick box" criteria that they check off as they complete.

We can review presentation videos and wikis to determine what winning teams did to score well on all of the aspects above except number 9. How *competent were the team members at answering judge questions?* To judge this aspect, judges will primarily use the discussion time during the Judging Session. Judges should remember that iGEM teams are interdisciplinary and each team member may bring different skills to the table. It is standard practice for teams to defer to the team member with the most knowledge on the topic to answer the question. Teams may also work together to overcome language barriers. These teams will confer together and allow the team member with the strongest English language skills to provide the answer. Thus, a judge should not expect every single team member to be able to answer all questions. The best iGEM teams will work together to provide an honest and thoughtful answer to each question posed by judges. Such teams should score well on this aspect.

To get a better idea of what judges recognize as exemplary on the other aspects in the Project section, we will explore a few finalists' projects:

- **GreatBay_SZ 2019** (https://2019.igem.org/Team:GreatBay_SZ)
- **Vilnius-Lithuania 2017** (http://2017.igem.org/Team:Vilnius-Lithuania)
- **McGill 2023** (https://2023.igem.wiki/mcgill)



GreatBay_SZ 2019

https://2019.igem.org/Team:GreatBay_SZ

The Team from Great Bay in Shenzhen, China, won the Grand Prize Award for High School Teams with their project on Spider Silk. Spiders create an unusually strong silk thread that can be woven into textiles. Spiders are not behaviorally amenable to cultivating colonies and/or herds for large scale harvesting of their thread. Alternatively, the team set out to grow and harvest spider silk protein and organic red and blue dyes in *E.coli*. The long term vision of the project was to use their synthetic red and blue spider silk material to build an indestructible suit for Spiderman!

Figure 1 on their wiki provides an overview of their approach.

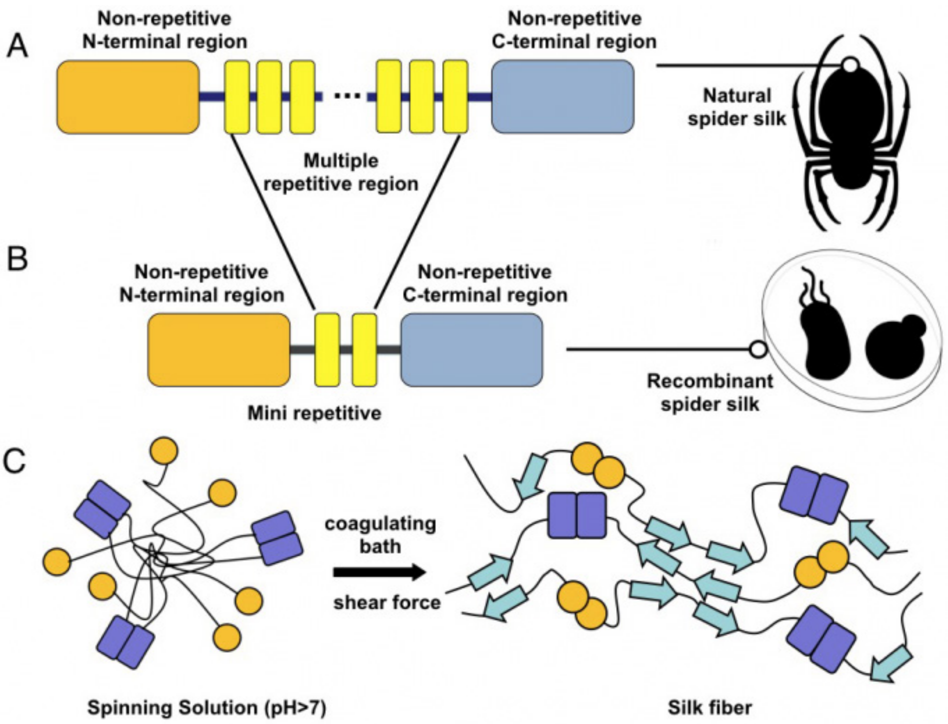


Figure. 1 Compare between natural spidroin structure and mini-spidroin structure. A.The structure of natural spidroin. B.The structure of mini-spidroin. C.The protein conformation due to alternating pH that forms silk.

The team first engineered *E. coli* to produce a version of the spidersilk (Figure 1A and 1B). Upon successful growth and purification of the protein, they needed to find an ideal solution and provide a shearing force to spin the fiber (Figure 1C). For the solution, they tested and observed results in solutions at various pHs. They found that spinning the silk in 100% isopropanol produced the best results. To provide a shearing force, they built a machine modified from the work of a previous iGEM team to spin the purified protein into a thread. After successfully developing a silk fiber from *E. coli*, the team went back to their original construct to optimize it. They varied the number of repeating regions in the construct and tested for strength and extensibility. They created a suite of constructs that could provide spider silk of varying characteristics.

To develop dyes, they chose red and blue dyes that are synthesized from a common precursor, tryptophan. They constructed plasmids with the genes necessary for the metabolic pathway for each dye. They produced and extracted the dyes from *E. coli*. Their initial blue dye extractions produced an insoluble dye. They collaborated with another team to redesign their blue dye construct. They showed that these dyes could color different kinds of fabric.

To create colored textiles that didn't require an additional dying process, they tried to build the color into the spider silk by redesigning the protein as a fusion between silk and dye proteins. They had varying results. The green fluorescent protein-spider silk fusion produced silk that fluoresces green under ultraviolet light. The red fusion protein produced an insoluble mass that could not be spun.

They decided to separately express and purify the spider and dye proteins. They then mixed them together before spinning. Of the three dye proteins they attempted, two of them produced the desired results. Using electron microscopy, they showed the resulting fibers in their Figure 15.

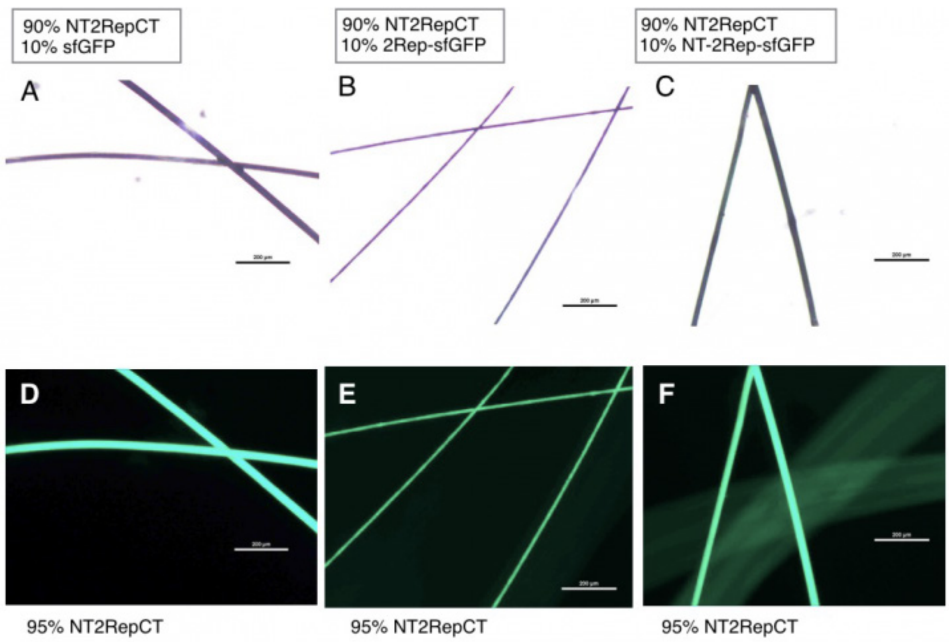


Figure. 15 Electron microscopy images of fibers formed from 90%NT2RepCT spidroin mixing with respectively 10%sfGFP, 10%2Rep-sfGFP, and 10%NT-2Rep-sfGFP. The fibers from sfGFP:NT2RepCT 1:9 (25.5um) (A), The fibers from 2Rep-sfGFP:NT2RepCT 1:9 (9.6um) (B), The fibers from NT-2Rep-sfGFP:NT2RepCT 1:9 (21um) (C) were made by artificial spinning. (A) (B) (C) are bright field image under electron microscope. (D) (E) (F) are dark field image under electron microscope.

Finally, they tried mixing different combinations of the dye proteins before the silk was spun. They successfully created various colors of spider silk from *E. coli*.

This project was extraordinary in the amount and quality of work the team achieved. They demonstrated where the project succeeded or failed. They discussed their failed results. They used iterative engineering to step back and fix parts of the project that weren't working. They walked through a logical sequence of increasingly difficult steps to produce a coherent story and elegant results. The project was documented well on their wiki and explained well during their presentation and poster sessions.

Their Human Practices informed every aspect of the project. They reached out to textile factories to shape their project; they consulted technical experts to inform their lab work; and they discussed businesses of various sizes to craft their entrepreneurship activities.

The team provided clear attributions for their work. A chart spelled out which team members did which part of the project. They listed references and thanked partners. They also referenced past iGEM teams who worked on similar projects.

The judges offered only minor constructive comments, suggesting areas of the project that might be strengthened or clarified. No iGEM project is perfect or complete, including the winning ones. More importantly, this team extremely impressed the judges with what they accomplished, documented and presented. The way the team thoughtfully considered and deftly approached a compelling problem earned their position at the top of many extraordinary high school teams in 2019.

Vilnius-Lithuania 2017

http://2017.igem.org/Team:Vilnius-Lithuania

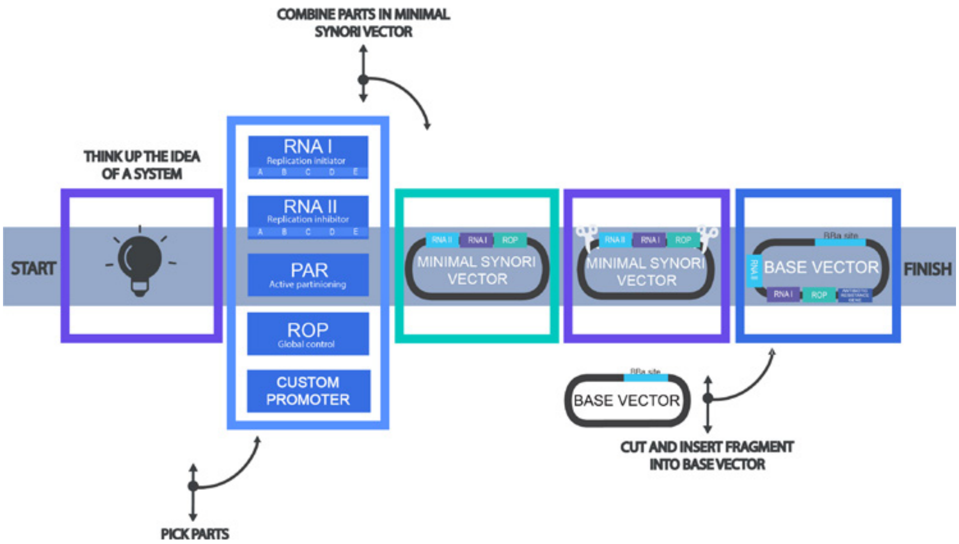
SynORI – a framework for multi-plasmid systems

The team's project focuses on the idea of a controllable, standardized multi-plasmid framework, which can easily be applied by future teams. Their project was the Grand Prize winner of the undergraduate section in 2017.

Team Vilnius-Lithuania's core idea looked at the balanced expression of multi-plasmid systems, where current negative impacts like plasmid loss, unbalanced replication or incompatibility of co-maintaining plasmids with different types of origins of replication, running out of useable antibiotic resistance genes, and issues with inheritance of the plasmids to daughter cells would be addressed, as well as solved, within their project.

Their solution to these fundamental but complex issues was using synthetic origins of replication (SynORIs) to manage the plasmid copy number (PCN). The newly designed ORIs were coupled with a selection system requiring only one antibiotic resistance gene for up to five different plasmids per cell and an active partitioning system to ensure plasmid stability during cell division.

The resulting system is adaptable for different scientific problems:

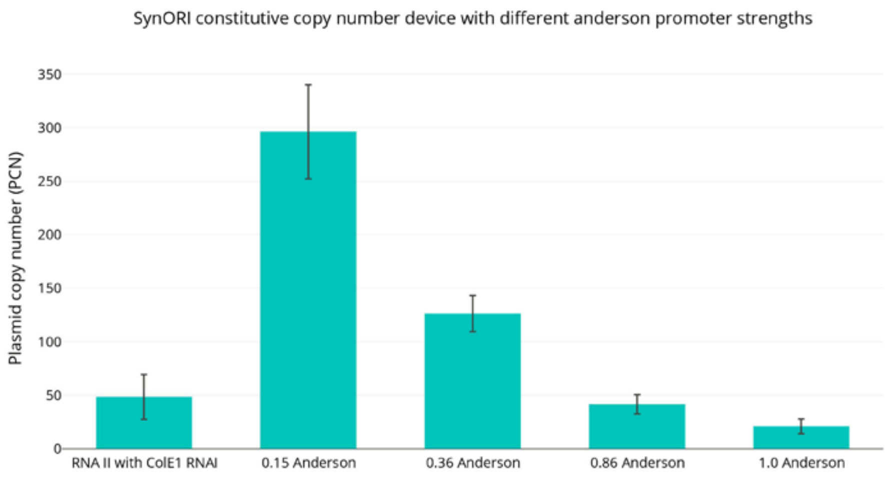


The team's vision is a standardized, easily adaptable system to be used for multi-plasmid systems of different purposes.

The team based their experiments on extensive literature research. They implemented their own ideas on the previously published information to tackle current issues in plasmid replication making this project creative and novel. In addition, as plasmids are extensively used in scientific research, industry, and iGEM itself, the project may likely have an impact in the field.

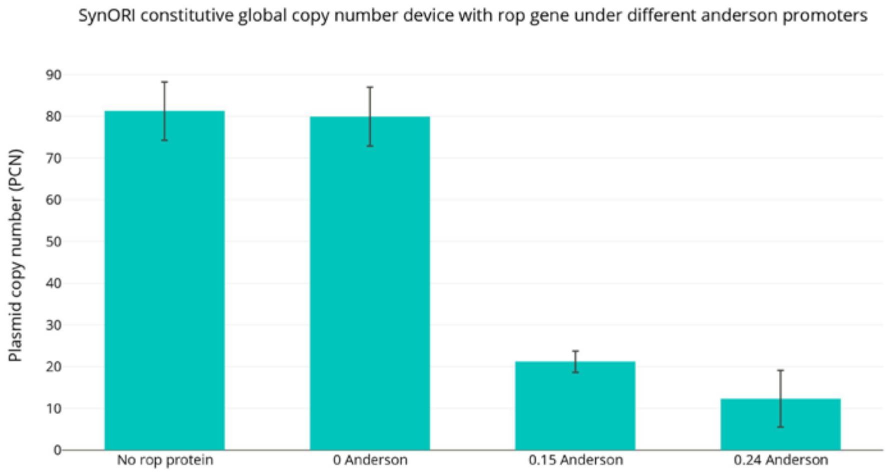
The team members first established a method measuring the plasmid copy number (PCN). Absolute quantitative PCR with specific primers to discriminate between bacterial and plasmid based ORIs were used. Next, the ColE1 ORI was re-engineered in order to gain control over the PCN. ColE1 consists of two antisense RNA molecules: RNA I and RNA II. RNA I is known to inhibit replication as RNA II is seen as the activator of replication. Vilnius-Lithuania marked the RNA I gene and its promoter as their primary target for designing their PCN device. Before starting the wet lab work, the core idea of RNA I reducing the PCN was successfully modeled by an ordinary differential equation approach.

RNA I and RNA II are two antisense molecules, so the team needed to separate the genes from one another, which was a novel idea and thus had not been done before. Subsequently, the team disabled the RNA I promoter. After disabling the promoter sequence they set the RNA I gene under the control of different Anderson promoters as well as a rhamnose promoter. Those constructs were placed next to the RNA II gene. Thus, they were capable of controlling the PCN in a constitutive and inducible manner.



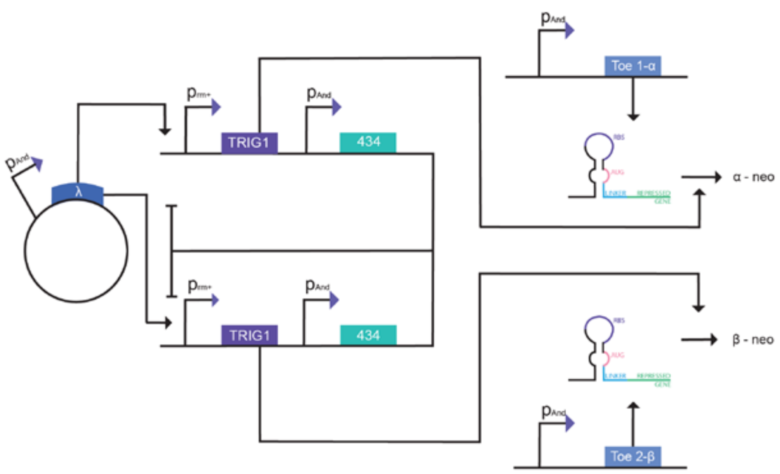
Constitutive control over the PCN by “exchanging” the native RNA I promoter with Anderson promoters of different strength.

After being able to control the PCN of a plasmid, the team established control over multi-plasmid groups and subsequently global control over all plasmid groups simultaneously. By testing different secondary structures of the RNA I and RNA II in search of the perfect interplay between RNA I and II, the Vilnius-Lithuania team achieved classification of and control over different multiple plasmid groups. Furthermore, they used the secondary RNA structure binding protein called Rop coupled to different Anderson promoters as a global copy number regulator.



Rop protein is used to control the PCN on a global scale. The strength of the Anderson promoter upstream of the rop gene is directly coupled to the PCN control.

Finally, the team needed a selection system to maintain high numbers of different plasmids in their system. Their approach was based on a split antibiotic resistance gene. The two parts of the gene were divided on two plasmids. If both plasmids were maintained in the cell, then the antibiotic resistance would work properly. Both parts of the antibiotic resistance gene were set under the control of dynamic riboregulators, called “toehold” switches. The switch harbored an RBS and a start codon in a linker sequence, which were both sequestered by a secondary RNA structure. By adding the right RNA trigger, the RNA duplex formation was initiated, resulting in the revealing of RBS and linker start codon. With this method, the team demonstrated the ability to maintain up to five plasmids in one cell.



The selection system for four plasmids (A) and five plasmids (B). The system is built upon a split antibiotic gene under the control of a “toehold” riboswitch.The switch itself is under the control of RNA triggers. The system can be expanded by a transcriptional factor to control the RNA triggers.

The practical work of the Vilnius-Lithuania team impressed the judges as it addressed an important need and aspect of everyday lab work. Furthermore, all subparts of the project were well-engineered and used standardized parts, and the team showed successful execution of their design. In fact, the judges scored them highest on their ability to demonstrate experimentally that their parts worked. They even won the Best Part Award (see page 72).

The team also took an extensive integrated Human Practices approach, which included talking to potential users of their product and stakeholders in the field. Beyond that, they thoughtfully engaged in the educational/public engagement aspects of Human Practices by developing an Augmented Reality framework for synthetic biology, to be used by teachers in schools. Additionally, they participated in public discussions, engaged in Bioart exhibitions, and discussions about Bioethics. Overall, the team's implementation of their initial ideas coupled with their Human Practices efforts made their work an impressive iGEM project.

McGill 2023

https://2023.igem.wiki/mcgill/

Overview of the Project:

McGill 2023 designed a modular CRISPR-based tool as a putative diagnostic and treatment for pancreatic cancer. By targeting a mutation in KRAS, a cell-proliferation driver with common errors in pancreatic cancer, using Caspase-7 and Caspase-11, they were able to engineer probes to drive pyroptosis in precancerous cells. Through their wet lab work, they were able to design and build individual constructs for use in model yeast systems, before attempting transfection into human-derived cell cultures.

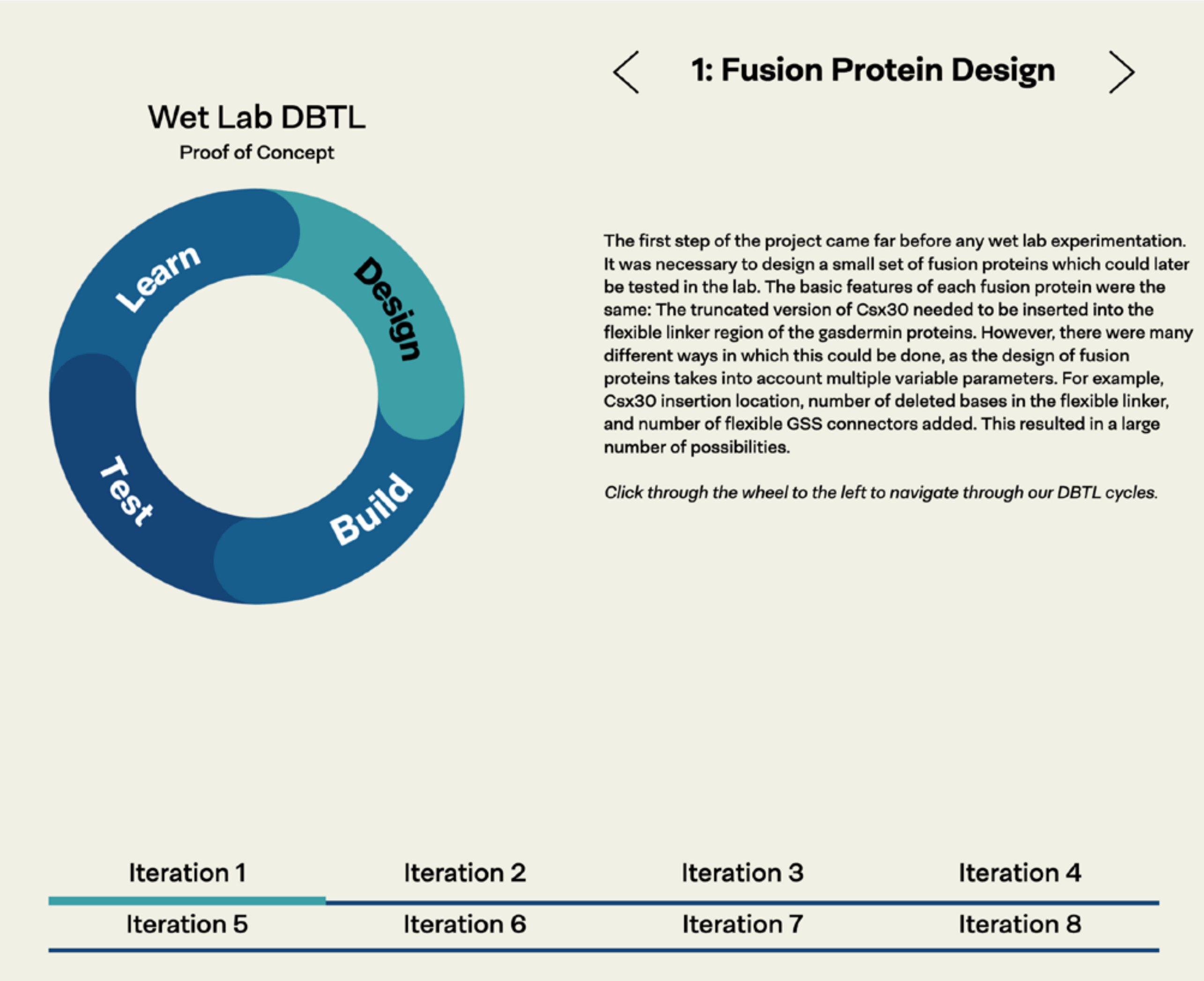
By binding RNA, the caspase was able to cleave a Gaspermin CSx30 fusion protein. This cleaved fusion protein then can form pores in the cell membrane, initiating pyroptosis, an inflammatory form of cell death. Through their work, they designed a modular system with a wide range of potential applications in targeting cancer types that typically evade immune responses as a means of metastasis. This system generated 4 new simple and 12 new complex parts, attributing each well to appropriate sources relevant to their design. This compendium of parts, inclusive of their descriptions of use, can serve as a benefit to any teams wishing to build on the design in the future.

This team led their scientific project in a human-centric manner throughout their project. By interviewing pancreatic cancer patients about their experiences in diagnosis and recovery, they were able to identify major gaps in care that lead to negative patient outcomes. With these interviews, the patient impact was at the center of their therapeutic development, rather than as an afterthought or bonus of their design. The focus on the patient impact is echoed in their human practices, as they identify possible shareholders for commercialization, mechanisms of synthetic biology education and expansion thereof, and how to ethically deliver the best product for these patients.

What impressed the judges:

Among what impressed the judges was the logical format of the wiki and how the team implemented engineering principles in their experimental design. Their wiki quickly highlights the problem: pancreatic cancer survival rates remain high due to inability to diagnose before late-stages of the cancer.

Multiple judges noted that they explained their proof of concept well and had ample experimental support for it. Their experimental design further showed thoughtful consideration of off-target effects as they integrated it into their design pipeline. Their design pipeline and engineering success was made clear through the interactive animation on their wiki (see static image below); when the reader clicked on the a step in the Design-Build-Test-Learn image, text appeared describing exactly what the team accomplished during that portion of the cycle.

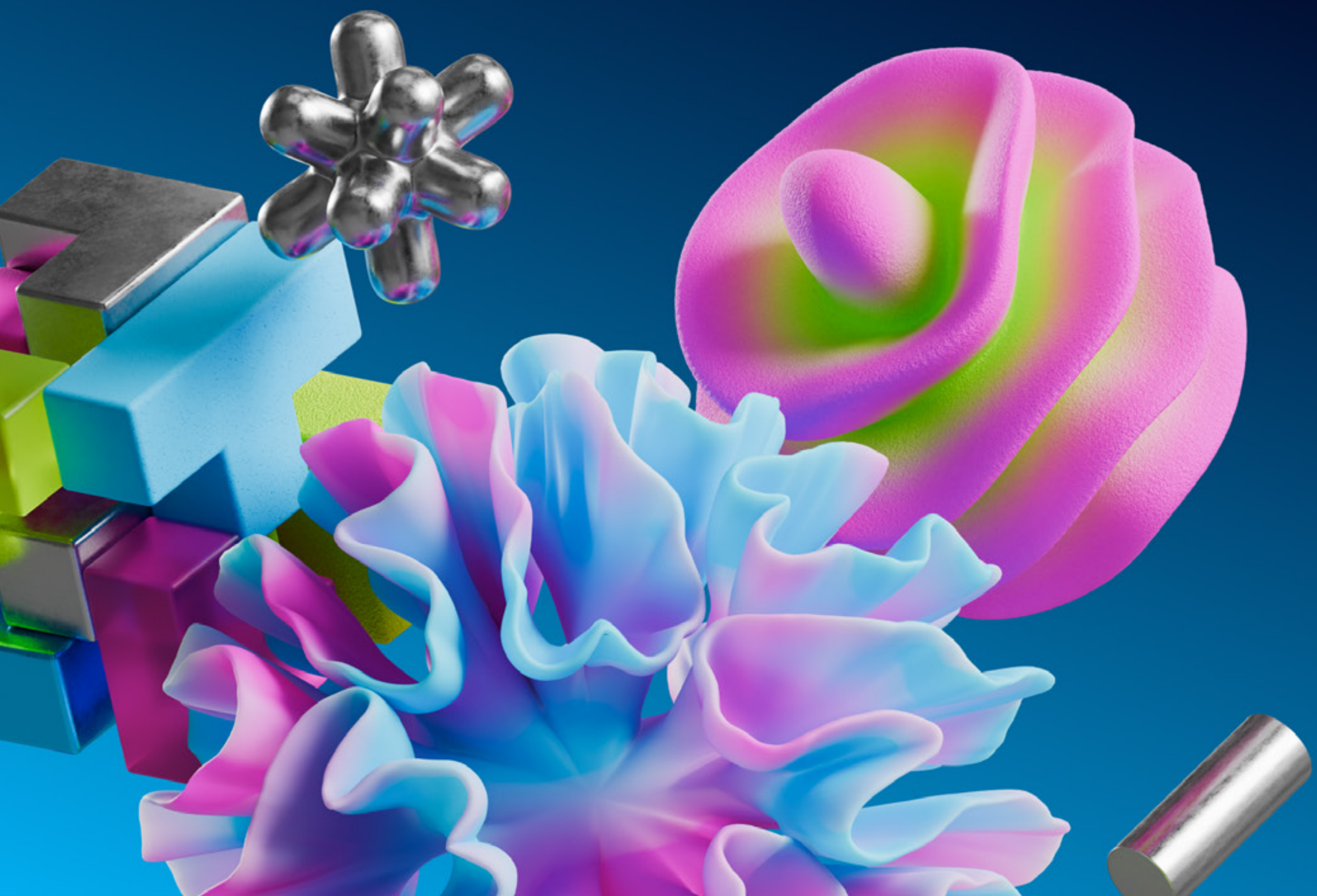


On top of the wiki and written aspects of their project, the judges praised their video presentation as excellent. The judges noted that each of the team members answered judge questions well and had sufficient background for thoughtful explanation of their project goals.

Through their efforts, they were awarded the grand prize for 2023, as well as the special prizes for Best Therapeutics, Best Parts Collection, Best Presentation, and a Nomination for the Best Wiki.

CHAPTER 3

Medals



Introduction

Summary:

- Teams earn medals by meeting specific criteria.
- Teams compete against themselves for medals; they should not be compared to other teams when assessing these criteria.
- Many medal criteria can be assessed by following the standard wiki page links in the Judging Ballot. If sufficient information to meet a specific medal criterion or award cannot be found under its corresponding wiki page, you can choose to consider the requirement unmet.
- It is up to the teams to convince the judges that they have achieved the requirements and/or criteria.
- While medal criteria can be discussed with other judges, every judge must make their own decision about whether a criterion is met; your vote does not reflect consensus of any group.
- Please do not discuss your personal medal decisions with teams EVER.

Medals allow us to recognize the accomplishments of all our iGEM teams. Through medals, we highlight the underlying values of iGEM: integrity, good sportsmanship, respect, honesty, celebration, cooperation, effort and excellence. We do not limit the numbers of each medal awarded, and all teams can earn a medal. Teams are only competing with themselves to achieve the medal criteria.

The three levels of medals, from lowest to highest are: Bronze, Silver, and Gold, with each medal building upon the next. For a Bronze Medal, teams must meet all four Bronze Medal criteria. For a Silver Medal, teams must meet the Bronze Medal criteria and additionally fulfill the two Silver Medal criteria. For a Gold Medal, teams must meet all Bronze and Silver medal criteria and additionally impress the judges with their work on three Special Prizes of their own choosing. Details of each criterion are described in the rest of this chapter.

Celebrating Their Work: What each medal means

- A Bronze medal is awarded to those teams that have participated in iGEM, presented their work, and made a contribution for future teams.
- A Silver medal is awarded to those teams that have additionally addressed these pillars of an iGEM project: Engineering Success and Human Practices.
- A Gold medal is awarded to those teams that have shown excellence in three areas beyond the Silver medal in General Biological Engineering and chosen Specialization(s).

What about Parts?

If a team is working with Parts for any medal criterion those **Parts must be added to the Registry and documented on the relevant Part's pages**. (Also see page 18).

Medal Criteria Details

Bronze UPDATED

All criteria must be met

Criteria	*Guidance Provided to Teams*
1. Competition Deliverables. Complete the following Competition Deliverables: Wiki, Presentation Video, Judging Form and Judging Session.	*For guidelines for each of the deliverable, please see the links below:* Wiki (https://competition.igem.org/deliverables/team-wiki) Presentation Video (https://competition.igem.org/deliverables/presentation-video) Judging Form (https://competition.igem.org/deliverables/judging-form) Judging Session (https://competition.igem.org/deliverables/judging-session) You can also directly navigate to these links from the Competition Deliverables Introduction page (https://competition.igem.org/deliverables).
2. Project Attributions. Describe what work your team members did, as well as what other people did for your project, using the standardized Project Attributions Form.	*For guidelines for this deliverable, please see this link:* Attributions (https://competition.igem.org/deliverables/project-attribution) Please note: Teams must use the standard form. Do not create your own form. The standard Attributions Form must be filled out completely, accurately and honestly. Please fill out every row and column. This includes typing descriptions of work in the “Specific Tasks” columns. It is better to include too much information here than too little. Do not get penalized because you did not fill out this form completely. For the best results, we recommend teams start filling out the Attributions Form early in the season and update it often.
3. Contribution. Make a useful contribution for future iGEM teams.	Teams must document their contribution and explain why their effort is a contribution to fellow iGEMers. There is no single definition of what a contribution should be. We invite teams to be creative and generous in the knowledge, data or tools they may provide to the community. A few examples of contributions are: • Add new documentation to an existing Part on that Part’s Registry page. (This could be new information learned from literature.) (This could be new data collected from laboratory experiments.) • Build upon an existing software or hardware tool. • Document troubleshooting that would be helpful to future teams. • Create a 3D printed piece of hardware and document how to make it.

Silver

All Bronze and all Silver criteria must be met

Criteria	*Guidance Provided to Teams*
1. Engineering Success. Demonstrate engineering success in a technical aspect of your project by going through at least one iteration of the engineering design cycle.	*Engineering success can be achieved by documenting your effort to follow the engineering design cycle: Design → Build → Test → Learn* • We invite you to think about ways to tackle and solve one or more of your project's problems and use synthetic biology tools and/or experimental techniques to generate expected results. • When you have completed the cycle once, think about and document what changes in design you would make for the next iteration(s) of the cycle. • For example, you can design and build a new Part, measure its performance, document whether it worked or not, and propose how the results could inform the next design or steps (documentation must be on the Part's Pages on the Registry). See the **Engineering pages** (https://technology.igem.org/engineering/introduction) for additional guidance on engineering success. Tip for judges: More judging guidance is available in the section "On Engineering" (page 15).
2. Human Practices. Explain how you have determined that your work is responsible and good for the world.	*Some questions to help guide you:* • What values— environmental, social, moral, scientific, or other—did you have in mind when designing your project? • Which resources or communities did you consult to ensure those values are appropriate in the context of your project? • What evidence do you have to show that your project is responsible and good for the world? • What impact will your project have? • Who are your proposed end users? • How do you envision others using your project? • How would you implement your project in the real world? *Note: You should draw on personal reflections, background research, and/or engagement with communities relevant to your project as you think about the above.* Please visit the **Human Practices pages** (https://responsibility.igem.org/human-practices/what-is-human-practices) for more information on how to carry out Human Practices work. Tip for judges: More judging guidance is available in the section "On Human Practices" (page 21).

Gold

All Bronze, Silver and Gold criteria must be met

Criteria	*Guidance Provided to Teams*
1. Excellence in Synthetic Biology. Impress the judges with your work towards three Special Prizes of your choice. You must demonstrate excellence in both General Biological Engineering and in at least one Specialization. Note: Software and AI Village teams cannot select the Software Special Prize as a Gold medal criterion. By competition rules, teams in the Software and AI Village are not eligible to win the Software Special Prize.	You can choose your Gold Medal criteria by selecting **exactly three** Special Prizes (https://competition.igem.org/judging/special-prizes) for which to compete. At least one of your three chosen Special Prizes must be from the General Biological Engineering category and at least one must be from the Specializations category (see below). The teams may choose a third Special Prize from either category. You do not have to win any Special Prize awards to meet the Gold Medal criteria, but you do have to impress the judges in your efforts towards each Special Prize you select. • **General Biological Engineering** Pick at least one special prize from this list: *1. Measurement* *2. Model* *3. New Basic Part* *4. New Composite Part* *5. New Improved Part* *6. Part Collection* • **Specializations** Pick at least one special prize from this list: *1. Education* *2. Entrepreneurship* *3. Hardware* *4. Inclusivity* *5. Integrated Human Practices* *6. Plant Synthetic Biology* *7. Safety and Security* *8. Software* *9. Sustainable Development* The third Special Prize selection can come from either list. Teams may select fewer than three special prizes, but they will not qualify for a Gold Medal. You will select three prizes when you fill out the Judging Form (https://competition.igem.org/deliverables/judging-form) and document your work on the related Standard URLs (https://competition.igem.org/judging/special-prizes) on your Wiki (if applicable to your chosen prizes).

Standard Pages for Medals UPDATED

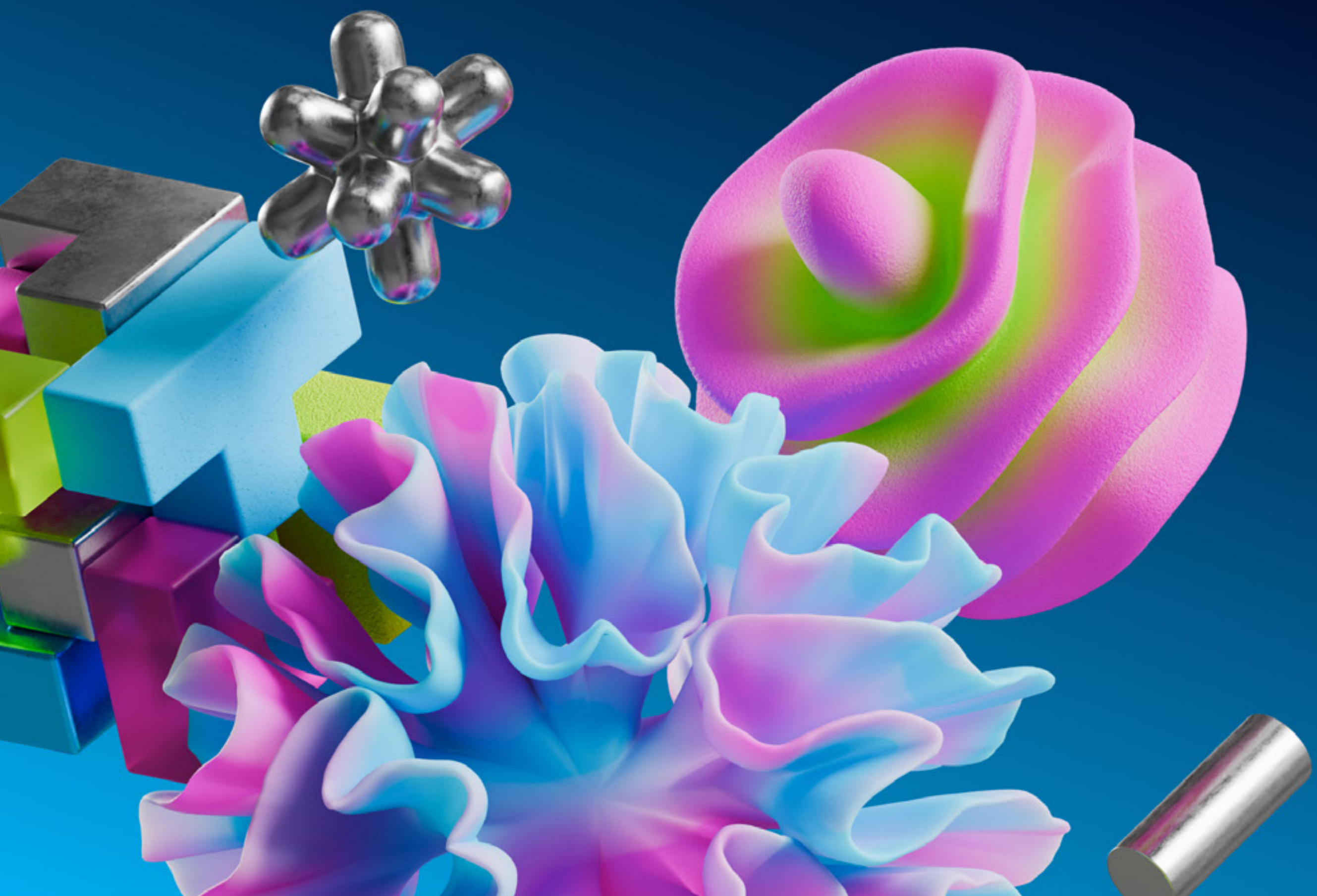
Below are standard links to the team "Example" template pages for the medal requirements. For team pages, you can find links directly to these Standard Pages on the Team's Judging Ballot through your Judge Dashboard.

Medal Criterion	*Standard Page URL*
Bronze #2 Project Attributions*	https://2025.igem.wiki/example/attributions
Bronze #3 Contribution	https://2025.igem.wiki/example/contribution ***If using a part to fulfill this criterion, documentation must be on the Part's Main Page on the Registry.***
Silver #1 Engineering Success	https://2025.igem.wiki/example/engineering ***If using a part to fulfill this criterion, documentation must be on the Part's Main Page on the Registry.***
Silver #2 Human Practices	https://2025.igem.wiki/example/human-practices
Gold #1 Excellence in Synthetic Biology	Document your work on the Wiki as required by the Special Prizes you select (see Chapter 4, Special Prizes, page 46).

**The Attributions deliverable has additional guidelines for how it must be displayed on a team Wiki. In summary, teams must use the standard form. They cannot create their own form or format. Any attributions information on the Wiki that is not a part of the standard form should not be accepted or judged. More information is available here:* https://competition.igem.org/deliverables/project-attribution.

CHAPTER 4

Special Prizes



Introduction

Special Prizes are awarded to teams in iGEM who excel in specific areas of the competition. All Village teams are eligible for Special Prizes, with one exception: Software and AI Village teams are not eligible for the software tool special prize. For a prize to be awarded, the highest ranked team must be scored high enough to meet a minimum performance standard (i.e., a prize will not be awarded if there are no nominated teams with high enough scores).

Teams may elect to compete for up to three Special Prizes. If they are seeking a gold medal, the team must select these three prizes based on the Gold Medal Criteria (see page 44). Teams cannot apply for more than three Special Prizes total, whether they are seeking a gold medal or not. The limit is intended to encourage the teams to focus on quality over quantity in their efforts to excel in the competition.

Please note that, outside of the three-selection limit for Special Prizes, all teams are still eligible to become a finalist and to win any of these additional prizes:

- Best in Village (See page 26, "What Happens When I Cast a Vote?" and the website (https://competition.igem.org/judging/project-prizes) for details)
- Best Wiki
- Best Presentation
- The iGEMer's prize (Voted on by iGEM teams)
- The Best Promotion Video (Voted on by iGEM teams)
- The Chairman's Award

The Judging Committee hopes to award the following Special Prizes, conditional on the accomplishments presented by the teams:

1. **Best Education**
2. **Best Entrepreneurship**
3. **Best Hardware**
4. **Inclusivity Award**
5. **Best Integrated Human Practices**
6. **Best Measurement**
7. **Best Model**
8. **Best New Basic Part**
9. **Best New Composite Part**
10. **Best New Improved Part**
11. **Best Part Collection**
12. **Best Plant Synthetic Biology**
13. **Best Presentation**
14. **Best Safety and Security Award**
15. **Best Software Tool**
16. **Best Sustainable Development Impact**
17. **Best Wiki**

Standard Pages for Special Prizes UPDATED

Teams need to edit the following standard pages to compete for the specified award. The listed links are for the team Example. For a team's own pages, they must replace "example" with their team name. You can find links directly to these pages on the Team's Judging Ballot through your Judge Dashboard.

Medal Criterion	*Standard Page URL*
Education	https://2025.igem.wiki/example/education
Entrepreneurship	https://2025.igem.wiki/example/entrepreneurship
Hardware	https://2025.igem.wiki/example/hardware
Inclusivity Award	https://2025.igem.wiki/example/inclusivity
Integrated Human Practices	https://2025.igem.wiki/example/human-practices
Measurement	https://2025.igem.wiki/example/measurement
Model	https://2025.igem.wiki/example/model
Plant Synthetic Biology	https://2025.igem.wiki/example/plant
Safety and Security Award	https://2025.igem.wiki/example/safety-and-security
Software Tool*	https://2025.igem.wiki/example/software
Sustainable Development Impact	https://2025.igem.wiki/example/sustainability

∗Teams applying for Software Tool prize MUST also host the source code of their software on the dedicated repository of iGEM's GitLab. (https://gitlab.igem.org/2025/software-tools/)

Special Prizes and Awards with no required Standard Page

These Special Prizes do not have Standard Pages. Rather they are documented and/or judged in other ways listed below.

Special Prize	Guidance Provided to Teams
Presentation	Based on the evaluation of your Presentation Video
Wiki	Based on the evaluation of your entire Wiki
Village Awards	Based on total body of work, not any specific page
All Part Prizes (Incl. New New Basic Part, New Composite Part, New Improved Part, Part Collection	Based on the documentation in the Registry for each designated Part • You will enter the Part(s) number(s) on the Judging Form for the selected part prize • Although not required, Teams can add additional pages to their Wiki to describe their best parts and how they fit into their project

Education

Summary:

- Recognizes exceptional efforts to include more people in shaping, contributing to, or participating in work in synthetic biology by providing new tools, knowledge and opportunities.
- Teams should show how their activities establish mutual learning and/or a dialogue with new communities about synthetic biology.
- Activities do not have to be directly related to the team's project, but may look at wider issues related to iGEM or synthetic biology.
- Teams should **not** "proselytize" or "market" iGEM and synthetic biology by telling the community that synthetic biology is great and will "save the world."

The Education prize is evaluated on the following aspects:

1. **How well did their work promote mutual learning and/or a dialogue?**
2. **Is it documented in a way that others can build upon?**
3. **Was it thoughtfully implemented?**
4. **Did the team convince you that their activities would enable more people to shape, contribute to, and/or participate in synthetic biology?**

Let's explore a few examples of exceptional Education work (previously "Education and Public Engagement") from previous years:

UCopenhagen 2020

https://2020.igem.org/Team:UCopenhagen/Education

The UCopenhagen 2020 team explored multiple ways to engage in education and public outreach activities. The team wrote and illustrated a children's book about transformation with the goal of engaging both children and their parents about synthetic biology. The team also taught high school students about some of the biotechnology used in synthetic biology. With the help of the SynthEthics start-up, the UCopenhagen team also ran an ethics workshop for high schoolers. And the team also discussed their plans to develop a biosenso-r kit for the Biotech Academy, which is a non-profit educational organization affiliated with the Technical University of Denmark.

William and Mary 2015

http://2015.igem.org/Team:William_and_Mary/Practices

and William and Mary 2018

http://2018.igem.org/Team:William_and_Mary/Human_Practices/A_Statewide_Standard

We encourage teams to collaborate with established educators. The William and Mary 2015 team developed educational activities based on feedback from public workshops they held in order to understand concerns about and hopes for synthetic biology. They developed an educational activity booklet with procedures, background information, materials and costs, critical learning questions, and learning goals. The activities were designed to be low-cost and based on materials accessible to teachers, suitable for instructors with limited biology background, and adaptable to any age or educational background. A particularly impressive aspect of the William and Mary team is how they built on their engagement with their state's public education system over multiple years. The William and Mary 2018 (http://2018.igem.org/Team:William_and_Mary/Human_Practices/A_Statewide_Standard) team worked directly with the Virginia Department of Education to establish a new curriculum standard that included the "biological and ethical implications" of synthetic biology.

Montpellier 2018

http://2018.igem.org/Team:Montpellier/Public_Engagement#Art

The Montpellier 2018 team recognized that their project—use of the vaginal microbiota for contraception—concerned an aspect of society that is taboo in certain cultures and communities. They collaborated with non-scientific artists to help bridge the gap between the team and the broader community, presenting artists with a series of prompts (such as "what is a vaginal 'flora'?") and hosting an event with a local art association to present their responses. They also worked with an art school student to produce a comic book on synthetic biology and the vaginal microbiota which directly responded to issues and questions raised in their engagement with non-scientists.

Entrepreneurship

Summary:

- The Best Entrepreneurship special prize is for teams who have demonstrated entrepreneurial spirit in the design-build-test cycle of their project.
- Successful teams will have constructed a formal business plan based on customer needs, expert knowledge on feasibility, and created a minimum viable product that customers want to use.

A well designed business plan is an essential part of entrepreneurship in iGEM. The most successful teams seek and incorporate guidance from customers and industry experts. Teams can follow ideas like Lean LaunchPad to identify appropriate customers, seek their input and incorporate feedback as the plan is made. Appropriate academic, industry and safety experts also help teams determine product feasibility; identify the ideal market fit for the product; evaluate risks and benefits; and develop appropriate milestones and reasonable timelines for their business plan.

The Entrepreneurship Special Prize is judged according to the following aspects:

- **Has the team discovered their first potential customers and identified any unmet needs not yet covered by other existing solutions?**
- **Has the team shown that their solution is possible, scalable and inventive?**
- **Has the team presented logical product development plans with realistic milestones, timelines, resources and risks?**
- **Has the team outlined the skills, capabilities, and stakeholders required to be credible in developing their solution further?**
- **Has the team considered the positive and negative long-term impacts of their fully developed solution?**

Teams taking the opportunity to work on commercialization as part of their project could significantly increase their chances to take their project beyond the proof-of-concept stage towards an impactful, real-world solution to a pressing problem. Teams may even consider applying to an incubator or accelerator after iGEM, such as iGEM's own pre-accelerator program, the iGEM Startups Venture Foundry. The aim with this prize is to create the opportunity space to see what happens.

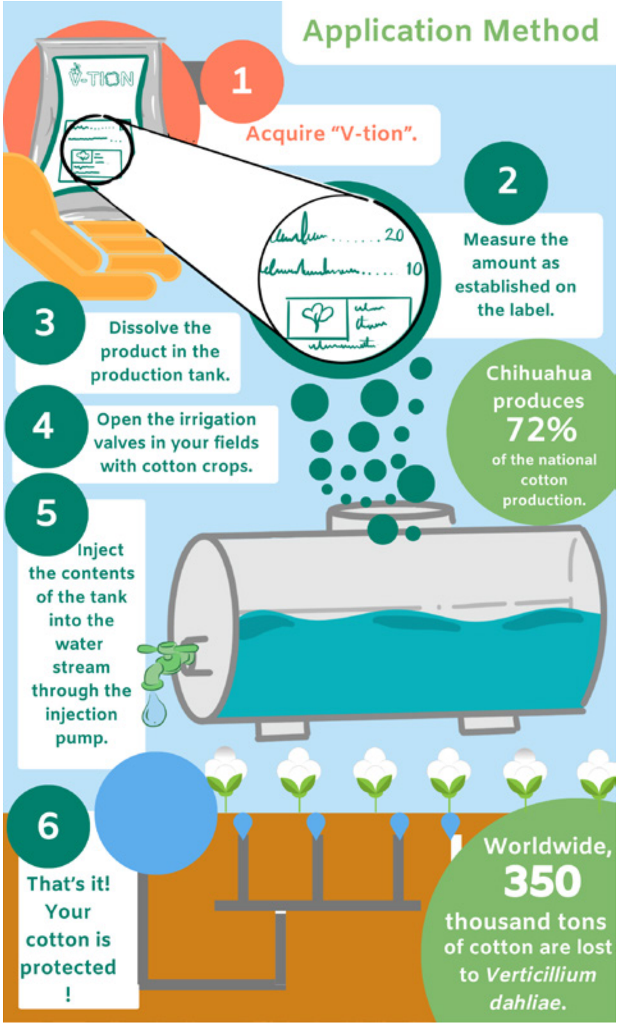
Let's look at some examples of great entrepreneurial projects:

TEC-Chihuahua 2019

https://2019.igem.org/Team:Tec-Chihuahua

Overview of the Project:

A spectacular example of efforts worthy of the Entrepreneurship Special Prize was presented by the 2019 team from Tec-Chihuahua. Many of their team members have connections or experience in local agriculture, and in their project they addressed Verticillium wilt, a plant disease that devastates many economically important crops, including cotton. Chihuahua state is the biggest cotton producer in Mexico, making this plant disease a big local problem. Verticillium wilt is a fungal infection caused by *Verticillium dahliae* and other species of *Verticillium* fungi, and amazingly there is no fungicide that is currently characterized for treatment or control of this plant disease. The 2019 Tec-Chihuahua team addressed this problem by developing a mix of three antifungal peptides that can attack the fungal pathogens to treat active infections as well as attacking fungal spores to prevent future infections. Incorporating information obtained from agricultural producers and engineers, the team developed their solution as a soluble powder that could be added to irrigation systems for easy delivery.



What impressed the judges:

Overall, the project was impressive because they developed a local solution that addressed a local problem and may have global impact. For their entrepreneurship efforts, they developed an economical solution to an unmet need with low barriers to adoption. The team excelled at identifying customers and their needs and using their feedback to shape their project throughout the business development process. The team made exemplary use of many standard tools for planning entrepreneurial ventures, including a value chain analysis to help identify stakeholders and keep an entrepreneurial focus up front, the design thinking process to incorporate new information from stakeholders into the project, a complete business model canvas to help clarify the viability of the venture and enable efficient communication, and a SWOT analysis to get a clear picture of how their project compares to other solutions to address the problem. The team clearly presented the results of these efforts in detail in their wiki. They also presented an impressive 20-page business plan, 2 letters of intent from future potential customers, and an acceptance letter into a startup incubator program to further support their efforts in entrepreneurship. All in all, the 2019 team from Tec-Chihuahua provided a shining example of entrepreneurship in iGEM, and they were recognized for this by winning the Best Supporting Entrepreneurship Award at the Grand Jamboree!

Exeter 2019

https://2019.igem.org/Team:Exeter

Overview of the Project:

The PETexe team's project revolved around tackling global plastic pollution, specifically targeting polyethylene terephthalate (PET) waste. PET is a widely used plastic in consumer products and packaging materials, and its accumulation in the environment is a significant problem. The team aimed to develop a biotechnological solution that could efficiently degrade PET, making it more eco-friendly and sustainable.

To achieve this, the team employed synthetic biology to engineer microorganisms capable of breaking down PET into environmentally friendly compounds. They identified and utilized various enzymes, such as PETase and MHETase, which could be integrated into the microorganisms' metabolic pathways for degradation. By optimizing the enzymatic activity and the overall performance of the engineered microorganisms, the team aimed to create an innovative solution to reduce PET pollution.

As for the special prize, "Entrepreneurship", the PETexe team demonstrated their entrepreneurial spirit by transforming their scientific project into a viable business venture. They identified their technology's potential market and commercial applications, targeting industries that rely heavily on PET materials. The team also considered the feasibility and scalability of their approach, outlining a business plan that detailed the production, marketing and distribution strategies to bring their technology to market. By focusing on the real-world impact of their project and seeking ways to turn their research into a practical solution, PETexe showcased a solid commitment to entrepreneurship in the 2019 iGEM Competition. The team's Business Model Canvas from their wiki is published here:

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
• University of Exeter: -Biosciences Department -Engineering Department -Innovation Centre • Washing machine companies such as Miele • Distributors and manufacturers of enzymes • Fashion / textile companies • Microplastics research groups	• Building filter parts • Further development of enzymes (lab work) • Lobbying government, research groups, larger corporations and general public about microplastic pollution from washing of synthetic fibres.	• Product = filter + enzyme: Helps customer capture and degrade their own microplastics • Product degrades rather than just capturing • Environmentally positive public presence • Increase customer awareness about brand integrating the filter • Fixes underperforming solution compared to competitors, reducing microplastics entering the environment	• Online via email, website and social media • Listen to feedback and use their ideas so that they feel engaged • Phone calls and face to face • Integrate their technology into our design	• Customer's measure success by increased sales, revenue and customer satisfaction • Companies are always looking to improve product for their customer's needs – their customers want to tackle microplastics (according to our market research and survey) • High quality brand so filter cannot negatively affect brand image
	Key Resources		**Channels**	
	• Relationship with stakeholders and washing machine for testing • University labs and support for both enzyme development and filter development		• Partner with distribution company • Partner with a washing machine brand and their relevant distribution companies	

Cost Structure	Revenue Streams
• Still unknown but some options are: 1. Patent and licence our filter to washing machine manufacturer – have enzymes produced externally and sold under our brand name 1. Manufacture the filters and enzymes in house & sell them as separate units, for customers to fit externally to washing machines. 1. Get a cut of profit from filtering washing machines.	• Sale of microplastic degrading enzymes • Sales of filter • Grants and investment

What impressed the judges:

The judges were impressed by various aspects of the PETexe team's project in the 2019 iGEM Competition, through their strong commitment to human practices, interdisciplinary approach, and focus on real-world impact. Their dedication to human practices was evident in their systematic application of the AREA and EDP frameworks, ensuring that their project was developed with stakeholder input and ethical considerations in mind. The team showcased the importance of collaboration and communication in addressing complex environmental issues by engaging with multiple stakeholders.

Their interdisciplinary project combined genetic engineering, integrated human practice, and entrepreneurship, reflecting the team's ability to work across different fields effectively. This collaborative approach was an example for future iGEM participants, highlighting the value of diverse skill sets and perspectives in tackling global challenges. Furthermore, the PETexe team's focus on real-world impact set them apart as role models. Their emphasis on the practical application of their technology, considering scalability and commercial viability, demonstrated their commitment to addressing the plastic pollution problem beyond the confines of the competition. Key aspects that made their project stand out for Entrepreneurship include:

- Market Identification: The team recognized the potential market for their technology, targeting industries that rely heavily on PET materials. By understanding the market landscape, they demonstrated a clear vision of how their solution could address a widespread problem.
- Commercial Applications: PETexe explored various commercial applications of their engineered microorganisms, showcasing their adaptability and potential for use in different industries, thus expanding their potential customer base.
- Feasibility and Scalability: The team considered the practical aspects of their solution, outlining a business plan that detailed production, marketing, and distribution strategies. Their focus on scalability allowed them to envision a more significant impact, addressing the plastic pollution problem on a global scale.
- Stakeholder Engagement: Engaging with multiple stakeholders, including industry experts and potential customers, provided valuable insights and feedback. This collaboration demonstrated their commitment to developing a solution that met the needs of their target market and could be successfully integrated into existing processes.

Overall, the PETexe team served as role models in the iGEM Competition by showcasing the importance of integrating human practices, fostering interdisciplinary collaboration, and prioritizing real-world impact in their project. These achievements inspire other iGEMmers and can guide future teams in pursuing innovative and impactful solutions.

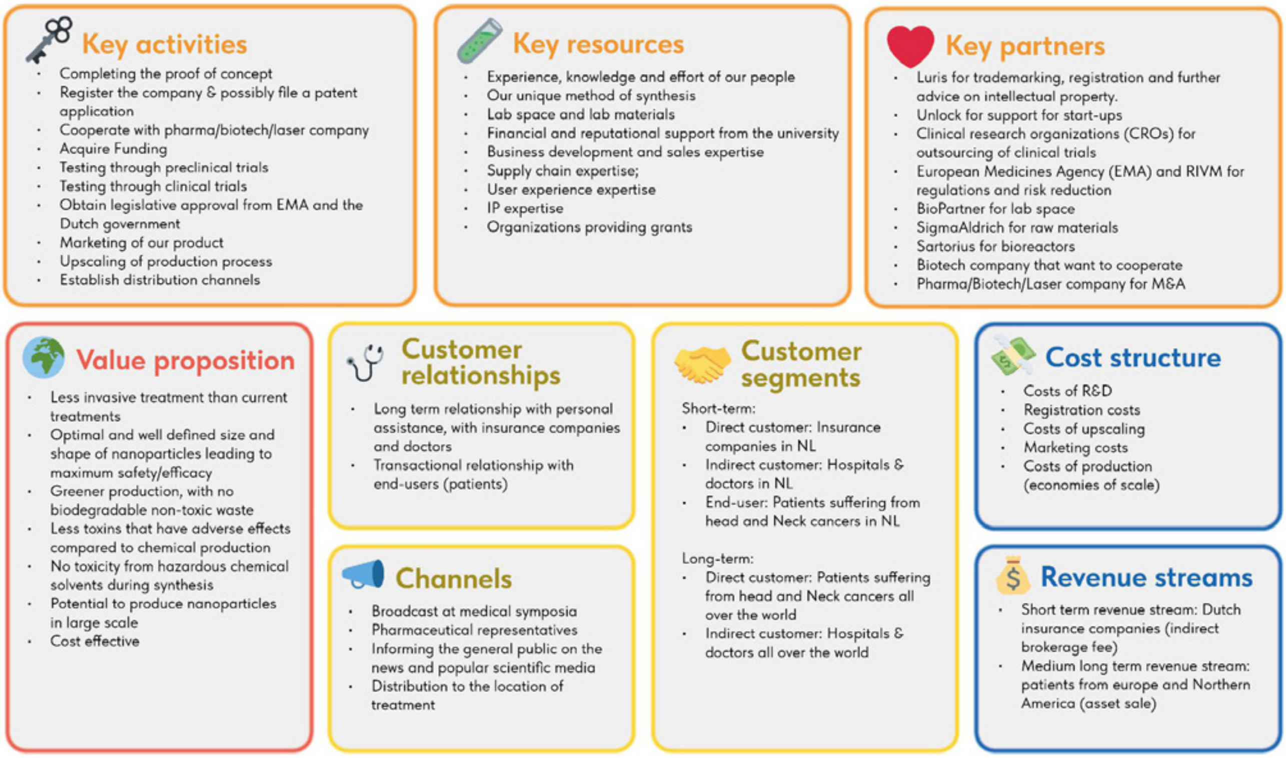
BINANOX

Leiden 2022

https://2022.igem.wiki/leiden/index.html

Overview of the Project:

The 2022 Leiden team noted that the current treatment options for head and neck cancers are extremely invasive and require patients to pick between treatment and quality of life. Their project aimed to design a less invasive alternative treatment using metal nanoparticle-based phototherapy (PTT). They conducted both a detailed investigation of the addressable market for their product, Binanox, and a very thorough risk assessment. They recognised that their product currently posed a high risk for toxicity. Their mitigation plan was to engage with experts that specialize in metal toxicity in tissues to find ways to reduce this risk and remove the barrier to reaching the clinical trials phase. Their business plan included a thorough SWOT and competitive analyses, production timeline, go-to-market plans, partners, distribution channels, a list of the resources they would need, and the cost structure. Their project also included an impact assessment of bringing their solution to market. See a summary of the business development plan in the figure below (Fig. 5 from their wiki.)



What impressed the judges:

Their well-designed wiki allows any reader to quickly skim the project and delve deeper into the details as they see fit. The business plan had many details as the Leiden 2022 team thoroughly developed a persuasive business plan. They built relationships with important mentors and stakeholders. They defined their mission and identified an unmet need. They explored market conditions and the effects those conditions would have on different business models (e.g., sales to consumers versus supplying to other nanoparticle companies). They compared their product to competing products. They identified and priced key activities related to intellectual property and regulatory approval. They demonstrated forward thinking and thorough consideration in the comprehensive business plan they presented at the iGEM Competition.

Hardware

Summary:

- The Hardware special prize was created to recognize the development of novel and useful devices designed to aid those working in synthetic biology
- Strong competitors for this prize will demonstrate utility, user testing, and easy reproducibility by those in the community.

Over the duration of iGEM, many teams have built hardware devices and brought them to the Grand Jamboree. The Hardware special prize was introduced to reward teams who took the time and effort to develop a unique piece of synthetic biology-related hardware.

For the Hardware special prize, the aspects are as follows:

1. **Does the hardware address a need or problem in synthetic biology?**
2. **Did the team conduct user testing and learn from user feedback?**
3. **Did the team demonstrate utility and functionality in their hardware proof of concept?**
4. **Is the documentation of the hardware system sufficient to enable reproduction by other teams?**

Let's look at a few hardware examples:

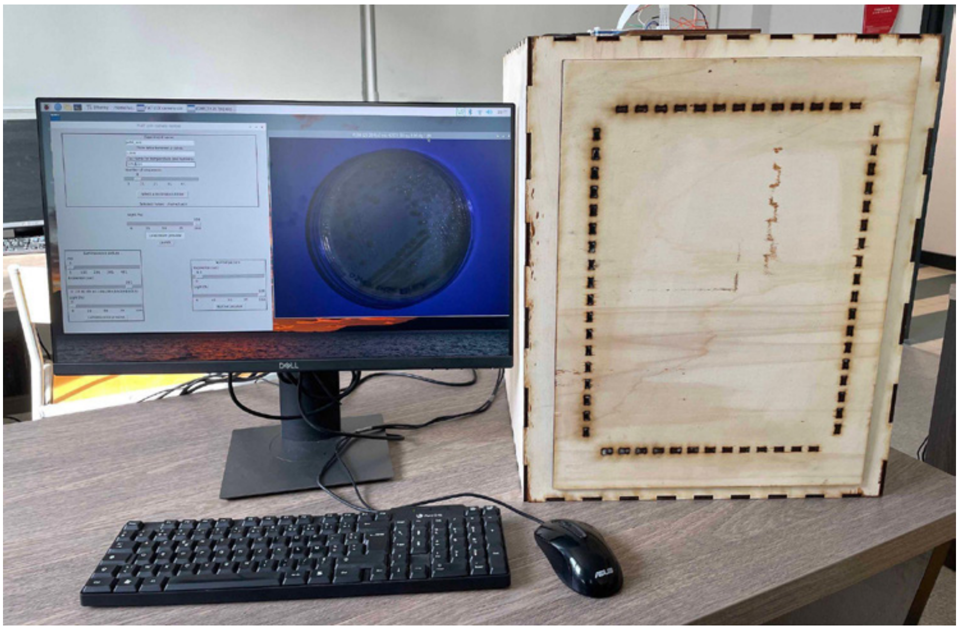
INSA_Lyon1 2022

https://2022.igem.wiki/insa-lyon1

Overview of the Project:

INSA Lyon1 2022 was the First Runner Up and the winner of the Best Hardware prize. The INSA Lyon1 iGEM team's project involves the development of a hardware device that can detect and quantify the presence of luminescence by bacteria in a non-intrusive manner, allowing the observation of bacterial propagation on a plant in real time. The device, called FIAT LUX box, uses a combination of an electric circuit board with light source and sensors, a camera, and software for acquiring and processing data.

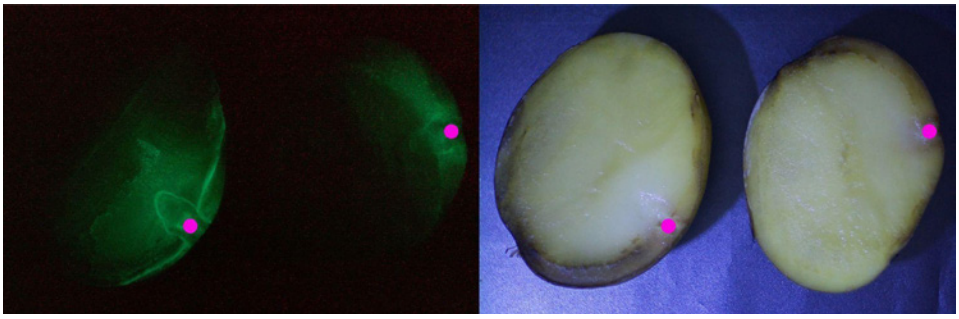
They provided a photo of their hardware: a box assembled with the HQ camera and the Raspberry pi. The computer screen shows the camera piloting software running.



What impressed the judges:

The judges were impressed by the team's end-to-end solution, which included the development of the FIAT LUX box for under $400. This low-cost hardware enables researchers and students to conduct experiments without requiring high-cost complex equipment. The team delivered comprehensive materials and documentation with an attention to detail. They also showed awareness of the possible benefits and drawbacks of their strategy and offered constructive criticism with concrete suggestions for improvement.

They demonstrated that their hardware worked. They labeled this photo from their wiki: "Observation of the luminescence in potatoes within our hardware. Potatoes infected with FIAT LUX containing bacteria (Dickeya solani). Left: photo showing the luminescence with 230 seconds of exposure. Right: normal photo (lighted with the LED matrix at 100%). Pink dots are [the] infection point."



Along with developing the device, software, models, and protocols, the team actively engaged with local and national stakeholders, both private and governmental. Overall, the judges were impressed with the team's comprehensive approach, which was supported by extensive and reliable synthetic biology work, and produced a usable and functional piece of hardware.

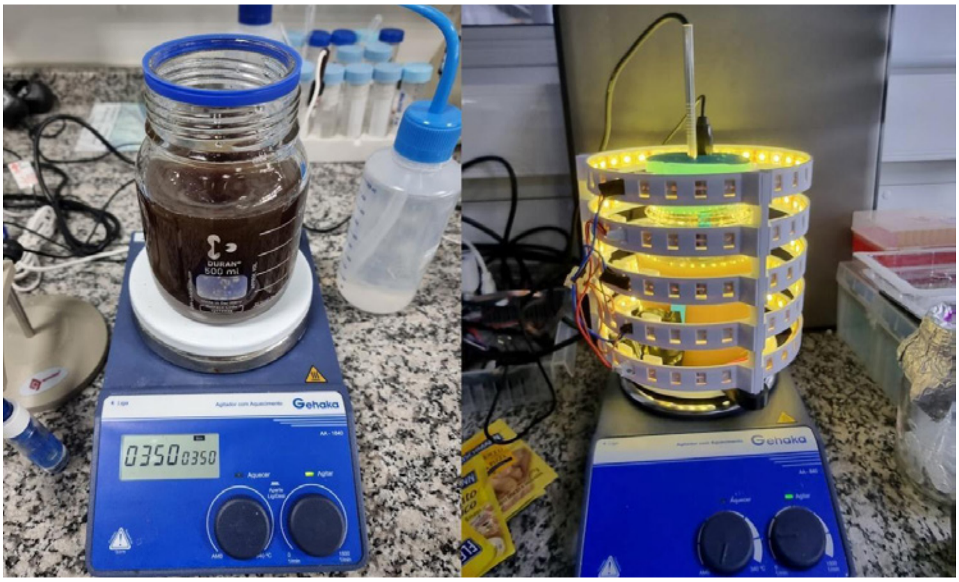
UFMG_UFV_Brazil 2022

https://2022.igem.wiki/ufmg-ufv-brazil/

Overview of the Project:

UFMG_UFV_Brazil worked on the eradication of helminthic infections, which affect up to one-fifth of the world's total population. The team genetically engineered a naturally occurring gut bacterium and common probiotic, *Lactobacillus acidophilus*, to produce chitinase, an enzyme that can damage helminth shells and their eggs. As a therapy, their engineered probiotic could both kill helminth worms and improve the gut health of the patient.

To develop such a therapy, researchers typically start testing the growth and capabilities of the new strain in benchtop reactors. These reactors can cost as much as 150,000 USD. To overcome the financial burden researchers may face, the team developed an open-source, small scale and low-cost (270 USD) bioreactor.



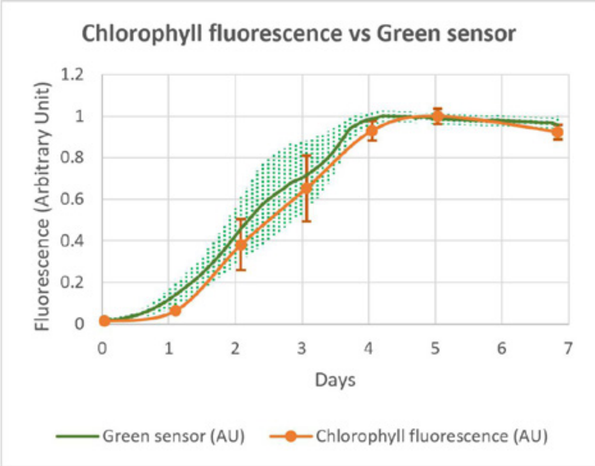
What impressed the judges:

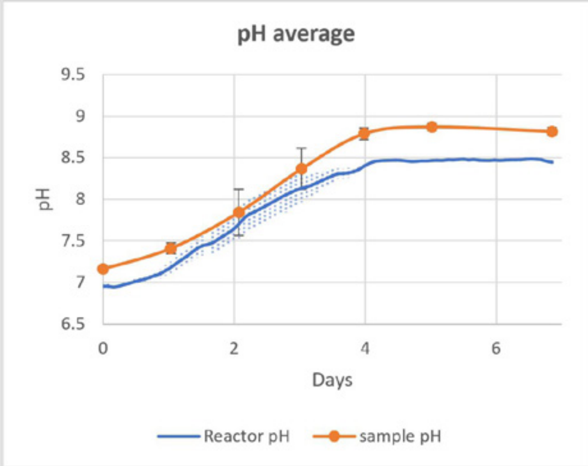
This bioreactor uses a Raspberry Pi 3 computer, 3D printed parts and other easily found materials. The cost of production comes at a fraction of that needed (270 USD versus 10,000 USD or more) for a Bench-top bioreactor. Furthermore, their bioreactor design is modular; the user can add only the specific needed items to optimize resources.

Easy-reproducibility of the bioreactor was achieved through detailed documentation for the materials used, assembly instructions and the testing conditions.

They also developed a web interface which allows the addition of sensors, the reading of online real time data, and the activation and deactivation of actuators.

Utility and functionality of the bioreactor were confirmed through the testing of at least 2 microorganisms, with the results shown in the next image.





Inclusivity Award

Summary:

- The Inclusivity Award is for teams who have explored ways to make scientific research (iGEM, synthetic biology, or STEM more broadly) inclusive of people with diverse backgrounds and identities.
- Successful teams will have researched barriers that prevent underrepresented groups from contributing to, participating in, and/or being represented by scientific research.
- Successful teams will have made exceptional and thoughtful efforts to eliminate these barriers, to create a more inclusive and representative scientific community.
- Activities for the Inclusivity Award do not have to be directly related to the team's project.

The focus of this prize is on allowing more people of the world to contribute to, participate in, and be represented by the scientific community. A more inclusive and representative scientific community will improve the quality and impact of scientific research. We hope that judges and teams both appreciate that promoting inclusivity is inherently challenging; it may require critical, sensitive discussions about privilege and power within our existing scientific and global structures. There may not be "perfect," "one-size-fits-all," or "immediate" solutions to these complex problems.

We are seeking teams that take a thoughtful and thorough approach to include individuals of at least one underrepresented identity in iGEM, synthetic biology, or STEM more broadly. Teams should demonstrate an understanding of what has led to the underrepresentation of their target group(s) in science, and should convince you that opportunities or tools they have identified or created would successfully help to expand access for these individuals. It is important for teams to show how opinions, needs, or values of the target group(s) informed the implementation of their activities, and that they have documented their work for others to replicate or build upon.

The Inclusivity Award special prize is judged according to the following aspects:

1. **How well did the work investigate barriers to participation in synthetic biology and/or science more broadly?**
2. **How well did the work expand access to synthetic biology and/or science more broadly?**
3. **Was there a dialogue with members of the target group, and were their needs, opinions, and values considered?**
4. **Is the work documented in a way that other teams or external entities can build upon?**

This award aims to empower teams to champion inclusivity and representation in science. Judges should do their best to understand how teams may uniquely define underrepresented individuals or groups and how they may approach building an inclusive scientific community in innovative and unprecedented ways. Some previous iGEM teams have strongly embraced this philosophy and demonstrated exceptional exploration of these issues.

Let's look at examples of great inclusivity projects:

Rochester 2020

https://2020.igem.org/Team:Rochester/Inclusion

Winner of the 2020 Inclusivity Award in the Undergraduate division.

Team Rochester 2020 tackled the language barrier within iGEM itself. The team worked to make their project more inclusive not only through spoken and sign language, but also through art. They recognized the importance of language accessibility in science by translating their social media posts into 10 different languages, including English, Mandarin, Japanese, Lithuanian, Arabic, Spanish, French, Danish and Hebrew, and by implementing American Sign Language (ASL) in their videos.

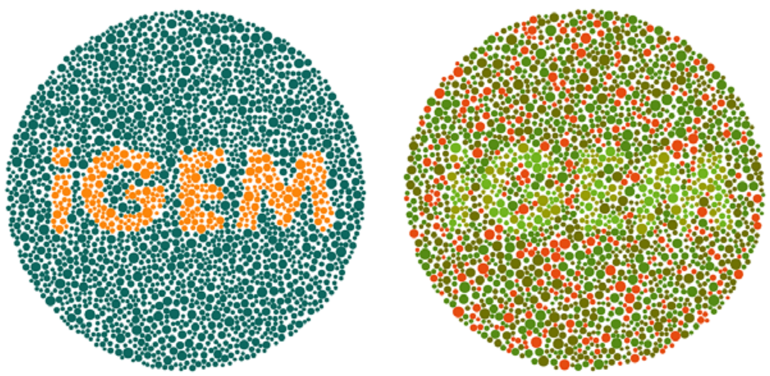
They also provided alternative text and captions in their media to promote awareness of endometriosis, and aimed to facilitate the integration of ASL vocabulary in synthetic biology. They worked to make not only their wiki and its content as accessible as possible but also their entire project, by designing their wet lab and hardware approaches to be accessible to low-resource areas, through adapting their diagnostic and hardware designs to be inexpensive and simple to use.

Leiden 2020

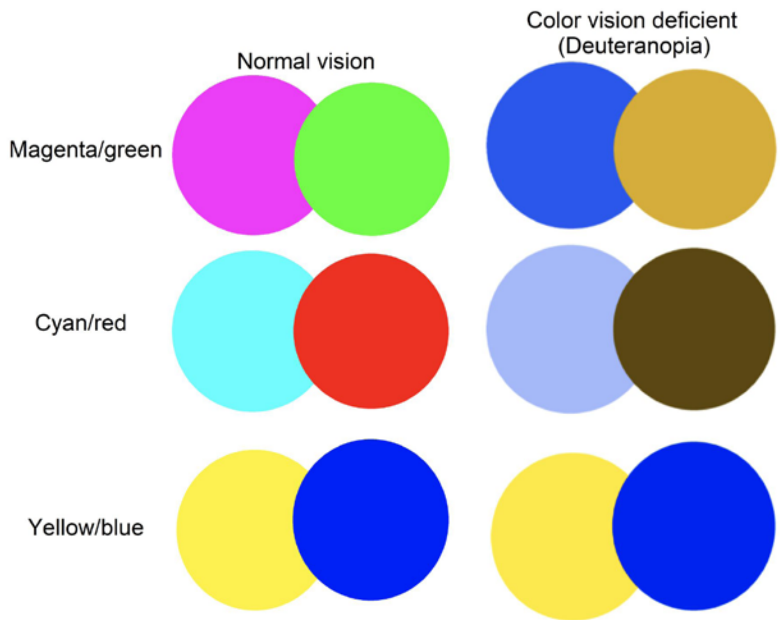
https://2020.igem.org/Team:Leiden/Inclusion

Winner of the 2020 Inclusivity Award in the Overgraduate division.

Team Leiden realized that color blindness can represent a major hindrance for researchers when interpreting color-based results. Their wiki, including all charts and graphs, were designed using only two main colors (#007972 and # fe9901), which can be seen and are clearly distinguishable to people with all types of color blindness, making the information fully accessible to them. The output of their diagnostic device is friendly to people with any of the different color blindness types. They even provided some Ishihara plates, so that readers of their wiki are able to test themselves for different types of color blindness. Team Leiden encouraged upcoming wiki designs and future scientists to be color-blind friendly, by informing team members about this condition, providing lists of online tools and filters, and suggesting strategies to tackle issues with results representation in report figures. The team recommended that color-blind persons should find assistive tools to better discriminate between colors in publications that are not color-blind friendly.



Visible for all | Color-blind only

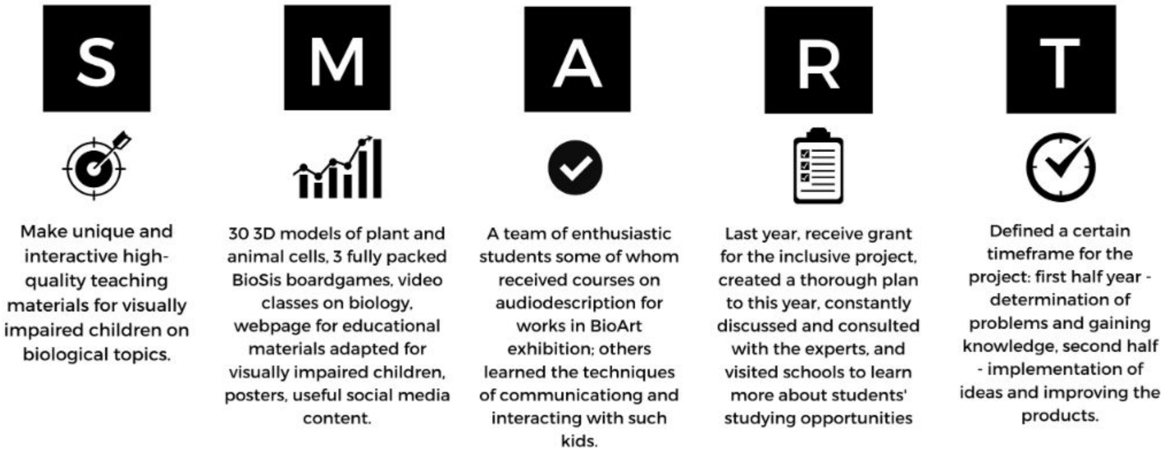


NU_Kazakhstan 2022

https://2022.igem.wiki/nu-kazakhstan/inclusivity

Team NU_Kazakhstan had the inclusivity goal to improve accessibility of education for all people in their country. After careful consideration between different groups in Kazakhstan, who experience a lack of accessible scientific information, the team decided to target fully or partially visually impaired schoolchildren.

The team built a very well-organized SMART model, which helped them to achieve their aim - to support the education of visually impaired schoolchildren.



The team began with getting useful insights from their target group - visiting specialized schools for students with visual impairments and meeting with a charity foundation. This helped the team to recognize the main difficulties that these children with disabilities experience while studying, and to give them ideas on how they can help those pupils with their scientific education.

They created RemiSee, a social project focusing on helping children with visual impairments with their studies by developing educational materials, such as tactile flashcards and an educational tactile board game. The team also organized a Bioart exhibition, accessible to visitors with visual impairments. The visitors of the exhibition had the opportunity to “experience” science by verbal descriptions, braille signage, touch tours and 3D tactile models.

The feedback the team got for their educational materials from the visually impaired children and from specialists in the area was very positive and constructive, and helped them to think of possible improvements and to plan the next steps for RemiSee. Many of the educational materials were added to the team’s wiki to be used by future iGEM teams.

Integrated Human Practices

Summary:

Teams should show how they have carefully considered whether their project is responsible and good for the world, not just at the beginning or end, but at many stages throughout their project's lifecycle, and that they have responded to these considerations.

Teams should document a thoughtful approach to exploring these questions. Their Human Practices activities should address both why their project responds to such questions, and how their proposed solution is implemented responsibly and reflectively.

Teams should show that they have created feedback loops between their project work and the world, and also demonstrate that the purpose, design and execution of their project evolved based on the information acquired through their Human Practices activities.

See "On Human Practices" on page 21 for more background and judging guidance.

The Integrated Human Practices prize is evaluated on the following aspects:

- **How well was their Human Practices work integrated throughout the project?**
- **How thoughtfully was it implemented? How well did they explain the context, rationale, and prior work?**
- **To what extent did they convince you that their Human Practices activities helped create a project that is responsible and good for the world?**
- **How well did it incorporate different stakeholder views?**
- **To what extent is the Human Practices work documented so that others can build upon it?**
- **How inspiring an example is it to others?**

Through these aspects we are seeking teams that:

- Used personal reflections, background research, and/or stakeholder and community feedback to inform their design/build/test/learn cycle and team decision-making from the project's beginning to end, and demonstrate how their project evolved based on Human Practices work.
- Convince you that their project reflects iGEM's values of integrity, good sportsmanship, respect, honesty, celebration, cooperation, effort and excellence, as well as public interests, and should serve as a model for others.
- Explain the context and rationale for their approach and reference prior work inside and outside iGEM that informed their approach.
- Clearly communicate the methods/processes and results of their work in their wiki and presentation, so that future teams can be inspired by and build upon their work.
- Show they have engaged with a diversity of views (not just their friends and family), and have a clear rationale for selecting relevant stakeholders and incorporating any feedback or research.
- Demonstrate they have conducted their work with care, foresight and creativity.
- Go the extra mile to investigate and document whether their project is responsible, good, and upholds the tenets of responsible conduct of science.

Let's explore a few examples of exceptional Integrated Human Practices work from previous years:

Bolivia 2021

https://2021.igem.org/Team:Bolivia/Human_Practices

The 2021 Bolivia team identified the problems of arsenic and high concentrations of metals in the water in Bolivia. They wanted to design and construct a bacterial biosensor to rapidly quantify water sample arsenic content. They took a human-centered approach and started with interviewing local leaders of urban communities, followed by visiting urban and rural communities, key organizations, and water treatment plants for more project-specific information, and also for understanding the communities' acceptance of synthetic biology. They found that many communities are influenced by the presence of arsenic in water and this need is not being addressed by higher authorities. The team also considered the potential project implementation thoroughly. They were aware this project does not solve the arsenic problem in the communities that they visited, but they think their actions allowed them to make the problems visible to support change.

Lambert 2021

https://2021.igem.org/Team:Lambert_GA/Human_Practices

Lambert's AGROSENSE addressed food insecurity by increasing efficiency of hydroponic systems via nutrient and pathogen biosensors. The project was a continuation of the previous year and the human practices built upon established stakeholder feedback. The team engaged with a wide variety of stakeholders from local farmers, non-profit organizations that provide resources to food insecure people, and government agencies. Their work with the Georgia State Department of Agriculture led to interactions with both regulatory and legislative branches of the State government to address safety concerns of using cell-free biosensors in-field. Additionally, the team developed hardware to address safety concerns of cell-free systems for the iGEM community. The team's aims were flexible and iterative based on continuous feedback from their human practice interactions. The final project was a reflection of the conversations throughout the process, and the team incorporated these into all aspects of their wet lab, hardware, software and education work.

SDU-Denmark 2023

https://2023.igem.wiki/sdu-denmark/human-practices

The SDU-Denmark 2023 team was trying to develop an efficient enzyme to prevent PFAS, a toxic chemical, from causing harm to humans and the environment by removing the harmful group of chemicals from the water system. The team started the project by exploring citizens' concerns, perspectives of Danish politicians, ideas from experts in PFAS pollution, and experience of large water system-related companies in order to find a more sustainable solution for PFAS disposal. They also tried to bridge the gap between scientists and the public by demystifying the technology. They addressed misconceptions and encouraged support and trust for responsible research practices. The team integrated stakeholders in their project design and developed a business-to-business model. A Value Proposition Canvas was used as a tool to understand and align the products, with the needs and preferences of customers.

Calgary 2019

https://2019.igem.org/Team:Calgary/Human_Practices

The Calgary 2019 team followed a human-centered design process to solve problems in the local canola oil industry. Before beginning lab work, they spoke to regulators, farmers and manufacturers about their idea to remove chlorophyll from canola oil. They discovered that synthetic biology could impact every stage of canola production, not just oil processing. The team expanded the scope of their project and iteratively developed solutions for chlorophyll extraction, frost prediction and seed grading. At each iteration, they re-engaged with stakeholders and technical experts to refine their design, closing the loop and producing a far better solution than they could have with a single round of feedback.

São Carlos 2019

https://2019.igem.org/Team:Sao_Carlos-Brazil/Human_Practices

The São Carlos 2019 team did additional research into the real-world policy context surrounding their project. They wanted to test their radiation resistance circuit by launching engineered bacteria into space on a stratospheric probe. However, they were unsure if this would count as an environmental release. They reached out to over 40 regulatory agencies of space and stratosphere use, and different nations gave wildly different answers about whether their work amounted to a "contained release." They carefully documented their interviews and the ways in which existing regulatory frameworks did not fit their work. In the end, they adapted their experimental plan by launching wild-type yeast strains on the probe.

Measurement

Summary:

- Teams are rewarded for either performing a stellar set of parts measurements (i.e., part characterization), or for developing a brand new measurement approach.
- Excellent teams will have data that is well documented, repeatable and useful.

The Measurement prize seeks to award activities that exemplify good measurement. When judging for the Measurement prize, there are four aspects upon which a team's score is based:

- **Could the measurement(s) be repeated by other iGEM teams?**
- **Is the protocol well described?**
- **Is it useful to other projects?**
- **Did the team appropriately use controls to validate the measurement process and calibrate units?**

Most of the documentation for this award should be easy to find on the team's standard wiki page. Other things to think about when evaluating and interacting with a team about this prize are the questions listed above.

When teams strive for excellence in measurement, they should also make sure they take the time to understand what methods came before and to think about what can be done to improve upon existing methods. This background information should be clearly stated on their wiki, and the team should convince you that they did due diligence when considering their measurement approach. More guidance on how to judge this prize is available in the section “On Measurement” (page 19).

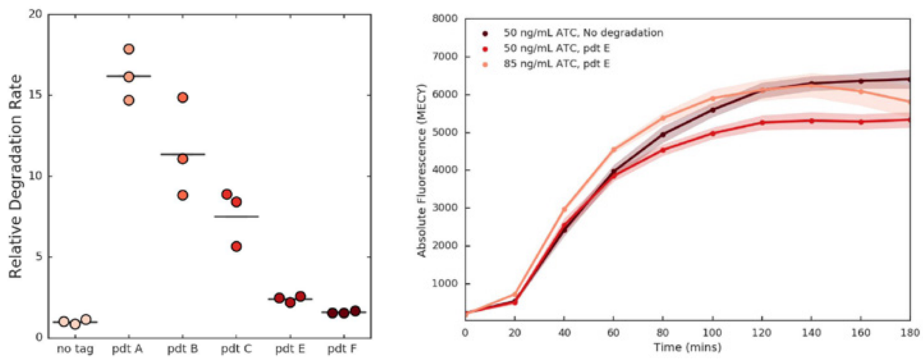
Let’s look at some measurement examples from previous years:

William and Mary 2017

http://2017.igem.org/Team:William_and_Mary

The William and Mary team focused on the characterization and control of the dynamical properties of genetic circuits. Using models to predict the type of data that was needed, they developed a time course measurement protocol that would allow robust and reproducible single cell measurements, including independent calibration of all measurements with fluorescent beads, with a well-documented protocol.

Throughout their project, team William and Mary ensured that their graphs followed the principles of good data visualization. They represented their categorical data in univariate scatterplots instead of using bar graphs, which can obscure the underlying distribution of the data. Additionally, they reported their fluorescence measurements using the geometric mean and standard deviation, which is the correct way to represent the magnitude and variability in fluorescent expression.



Examples of univariate scatterplot (left) and calibrated fluorescence graph (right).

TUDelft 2017

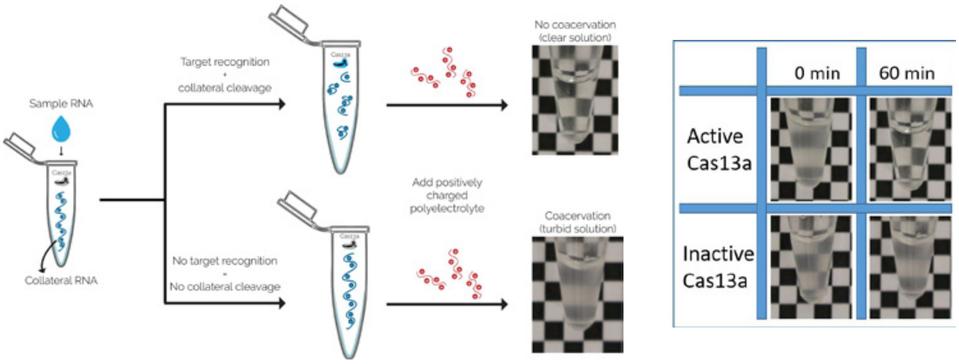
http://2017.igem.org/Team:TUDelft

An important aspect of team TUDelft’s portable on-site diagnostic assay for antibiotic resistance was to have a simple readout that did not require complex equipment or training. They developed a clever opacity-based readout called CINDY Seq that can be interpreted with the naked eye, and validated its performance under different usage conditions.

The team was able to demonstrate that their newly invented coacervation method, named Coacervate Inducing Nucleotide Detection of Your Sequence (CINDY

Seq), worked well without needing a full lab to analyze the results. CINDY Seq allows naked-eye detection of target recognition by Cas13a, exploiting the physical phenomenon called “coacervation”. In this phenomenon, mutually attracting polymers phase-separate into polymer-rich regions (known as coacervates) and polymer-poor regions if the polymers are long enough and the conditions are right.

TUDelft clearly explained how their measurement approach worked, with excellent documentation and illustrations to help guide their audience.



To achieve experimental proof of principle, experiments were designed and separated into three parts: Formation and visualization of coacervates, proof of principle with a non-specific RNase, and proof of principle with Cas13a. Their experimental design included two proof of principle experiments, which they tested in full with appropriate controls, and showed that each stage worked as expected.

Model

Summary:

A model is a mathematical or computational representation of a process or processes implemented in the project. The modeling efforts should in some way contribute to project design or contribute to a better understanding of the modeled process.

Excellent models will have well-documented development. This means that you (as a judge) should be able to understand:

- **What kind of modeling is being done and what information it will provide**
- **What assumptions were made and why**
- **What kind of data was used to build/assess the model**
- **How the model results affected the project design and development**

Many (but not all) teams will construct models to aid in the design, understanding, and implementation of their work. Often these are models associated with gene expression and protein function, but teams have also modeled cell behavior, and the behavior of systems or processes of which their engineered devices play a part.

In general, there is an emphasis on models that inform the design of parts or devices, based on real data, using modeling methods likely to be of use in the community. In the iGEM rubric, there are four aspects for model assessment:

1. **How impressive is the modeling?**
2. **Did the model help the team understand a part, device, or system?**
3. **Did the team use measurements of a part, device, or system to develop the model?**
4. **Does the modeling approach provide a good example for others?**

Let's look at some good examples for modeling in iGEM:

Vilnius Lithuania 2018

https://2018.igem.org/Team:Vilnius-Lithuania/Model

Overview of the Project:

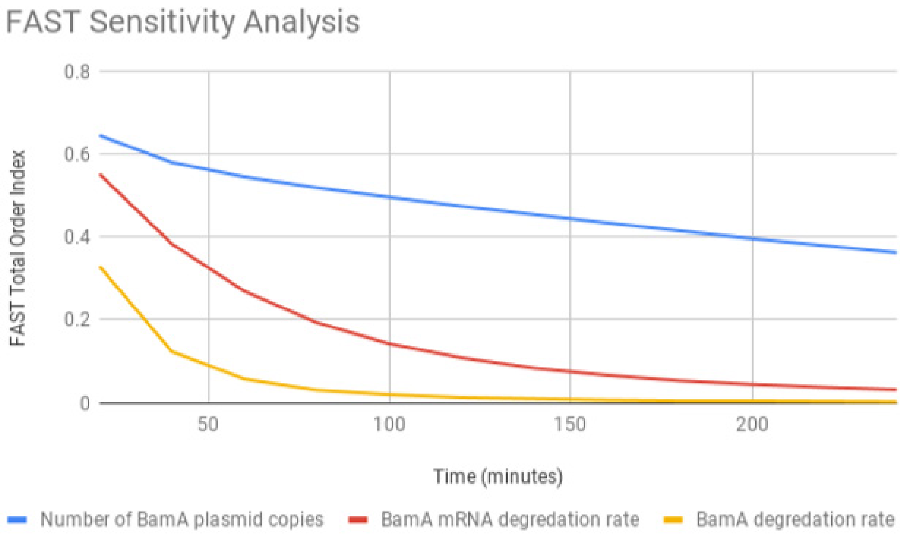
Modeling in synthetic biology has three main objectives: (1) providing a simulated storyboard of an imagined design that can then be used to effectively refine and communicate a plan to produce a realized system; (2) demonstrating a logical consistency in design that includes every component of the system and how they interact; and, (3) providing a "microscope" to explore every interaction between components in design-level detail such that it can then be used to explore and diagnose the realized system.

Team Vilnius Lithuania 2018 imagined a cell-free system to build membrane-bound protein displays. That system was envisioned as liposomes that contain an interior "genotype" compartment that would express protein using transcription/translation machinery, producing a protein display on the liposome exterior. They envisioned each liposome as an "experiment" that displayed its phenotypic result while retaining the genotype that produced it.

As a demonstration of the concept, liposomes could provide an antibody fragment display (phenotype) where the associated genetic encoding would be accessible in the liposome interior. We then can explore the diversity of sequence space and its relation to antibody binding affinity.

What impressed the judges:

For their project, expressed protein needs to be inserted into the liposome membrane before aggregates can form. The model showed that BamA concentration was the leading contributor to output variance, guiding the team to pre-load liposomes with BamA mRNA to promote successful processing of displayed protein (from their Wiki - Fig. 4 FAST sensitivity analysis of BamA).



Judges were clearly impressed with the clarity of the presentation, the understanding that was shared among all team members, and ultimately with the validation of the model as seen with production of liposomes. These comments show aspects of all three components of modeling objectives: (1) The judges praised the team's joint understanding of the realized system, and complimented the related team management and the defined roles of team members; (2) the discovery at design time of the possibility of membrane-protein aggregate formation imposed BamA mRNA preloading, and a requirement for ribosomes to be membrane-associated to maximize membrane insertion - these issues could have been costly to diagnose at build-time; (3) liposome production proved to be challenging in achieving proper size consistency. These parameters were not presented as part of the system model, though the presentation showed the team's engineering foundation in design-build-test-learn principles in resolving the issue.

In summary, the model was fully integrated with the engineering process - spanning imagining, learning, role refinement of team members, discovery of issues before implementation and diagnosing of issues post implementation.

HZAU China 2021

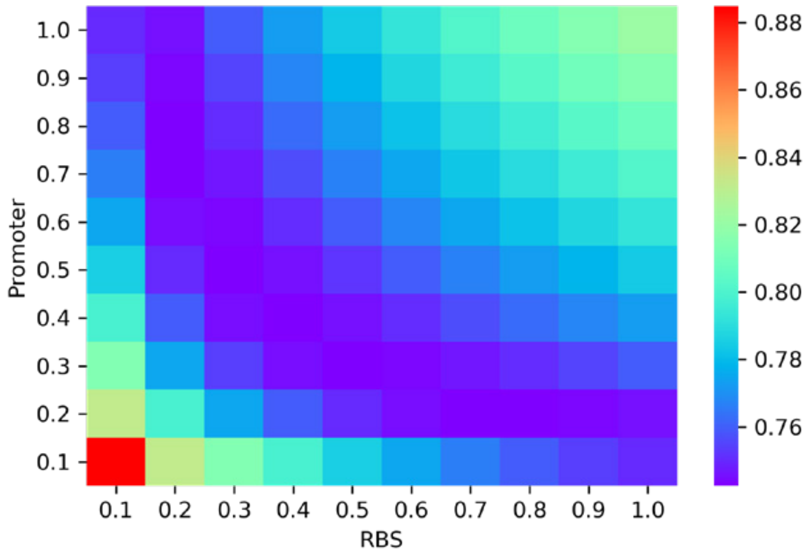
https://2021.igem.org/Team:HZAU-China/Model

Overview of the Project:

The team's project aimed to detect inflammatory bowel disease (IBD) in pets. When IBD occurs, the concentration of nitrate and thiosulfate in the intestine increases significantly. These molecules reflect the overall pathological changes in the intestine and are ideal biomarkers.

Team HZAU China 2021 called the different capabilities of their engineered bacteria modules. They demonstrated how they modeled the "Detect Module" to optimize its performance. Their circuit would detect increases in concentration of both nitrate and thiosulfate. They modeled three potential circuit designs: nitrate-dominant AND-gate, thiosulfate-dominant AND-gate and a thiosulfate-dominant OR-gate. The team used ordinary differential equation models for each circuit and determined that the nitrate-dominant AND-gate was the best design. Importantly, the team acknowledged that “we fail to match all the experimental results with the model simulations one by one, which indicates that our model has certain limitations.” This is a normal occurrence in research; it is *important and impressive that the team acknowledged what they could and could not accomplish with their modeling*.

From experimental results and literature searches, the team realized that the circuit performance was also affected by the strength of the promoter and the RBS. They admitted with surprise that the strongest promoters and RBS did not produce the highest protein expression, as they had expected. They proposed two hypotheses for these observations and tried to prove them by modifying their model further. Their final model results are shown in this figure from their wiki, Figure 12. The modeling of the NarX expression ratio.



In this figure the team demonstrated that gene expression intensity is not the maximum when the strongest promoter and the strongest RBS are combined, and the gene intensity under the weakest promoter and the weakest RBS is not the minimum. Through redesigning their model, the team was able to prove that the gene expression intensity is not completely related to the promoter or RBS strength.

What impressed the judges:

The judges were impressed that the team created a very ambitious design and they were able to accomplish a lot of the characterizations necessary to make it a possibility. The team did an excellent job of documenting how they built the model and chose their parameters which help them better understand their project. Their modeling presented a logical progression. They demonstrated the strengths and weaknesses of their models. Where they found limitations, they proposed modifications of their model to explain or account for them. They further tested these modifications to confirm their hypotheses and demonstrated an accurate model of their experimental results.

GEMS Taiwan 2022

https://2022.igem.wiki/gems-taiwan/model

Overview of the Project:

The team's goal was to engineer a soil probiotic to prevent disease in bananas caused by pathogens. They used three different models to examine three different aspects of their project. First, to estimate the environmental impact, they modeled how the pathogen FOC TR4 affects the global distribution of Cavendish bananas. They used MaxEnt software, which is an open-source software ecologists use to model species distribution. Second, to better understand the survival and efficacy of their engineered bacteria with a kill switch, they developed a series of ordinary differential equations. Third, to quantify how their prototype would benefit farmers in Taiwan should an FOC TR4 pandemic occur, they developed a bioeconomic model.

What impressed the judges:

The team used known models and software. However, their ability to use, describe and report their work was exceptional. They described each modeling effort as an academic paper, with sections for methods, results, discussion, conclusions and more. They included thorough references. For example, in "Table 1. Parameters for our Toxin-Antitoxin Model", from their wiki, they list the literature reference or iGEM team from which the parameter was taken.

Parameter	Description	Value	Reference
k_mccda	Translation rate of CcdA mRNA	1.33	(Gelens et. al., 2013)
k_ccda	Translation rate of CcdA	1.39	(UNILausanne, 2020)
C_n	Plasmid Copy Number	100	Estimated
d_mccda	Degradation rate of CcdA mRNA	0.203	(Gelens et. al., 2013)
d_ccda	Degradation rate of CcdA	0.0288	(Gelens et. al., 2013)
K_d1	Dissociation Constant of MA and mleR	0.9926	Estimated
K_d2	Dissociation Constant of MM and pmle	0.965	Estimated
B_0	Basal Expression	2000	Estimated (Renault et al, 1989)
B_0	Basal Expression	2000	Estimated (Renault et al, 1989)
k_mccdb	Translation rate of CcdB mRNA	1.33	(UNILausanne, 2020)
k_ccdb	Translation rate of CcdB	3.3	(Gelens et. al., 2013)
d_mccdb	Degradation rate of CcdB mRNA	0.203	(Gelens et. al., 2013)
d_ccdb	Degradation rate of CcdB	0.115524	(Gelens et. al., 2013)

They described the assumptions they used and included thoughtful discussion about what the modeling meant. For example, the second model helped them understand where in the environment their construct would thrive or be destroyed. This helped them form ideas about how to deploy and control the construct in the environment. Ultimately, they did not have time to experimentally measure the parameters they modeled and they noted that. Judges understand that the iGEM season is short. Teams should be praised for showing what they could accomplish, and for describing what they would do with more time.

New Basic and Composite Parts

Summary:

- The contribution of parts to the Registry is the fundamental backbone of iGEM. Prizes should be awarded to the best examples of part contributions.
    - Basic parts are single genetic components (e.g., RBS)
    - Composite parts are combinations of components (e.g., promoter+RBS)
- Parts must follow Registry guidelines (see below or the section On Judging Parts, pg. 18).
- Your role is to check for details and quality. The best parts should:
    - Be highly documented ***on the Registry***
    - Have ***detailed*** supporting data showing the part working
    - Have some novel and/or useful function

BioBricks are the main building elements of iGEM that allow other teams to build on the shoulders of previous teams. Since many teams incorporate basic parts into new devices, the impact of good BioBricks can be seen for years in the iGEM and greater synthetic biology communities.

There are four aspects for assessment that you should keep in mind as you evaluate Basic and Composite Parts:

Best New Basic Part aspects:

- How does the documentation on the Registry compare to BBa_K863006 (https://parts.igem.org/Part:BBa_K863006) and BBa_ K863001 (https://parts.igem.org/Part:BBa_K863001)?
- Did the team show the part works as expected (modeling data can be acceptable)?
- Is it useful to the community?
- How well characterized (experimentally measured or modeled) is this Basic Part when tested in a device?

Best New Composite Part aspects:

- How does the documentation on the Registry compare to BBa_K404122 (https://parts.igem.org/Part:BBa_K404122) and BBa_ K863005 (https://parts.igem.org/Part:BBa_K863005)?
- Did the team show the part works as expected (modeling data can be acceptable)?
- Is it useful to the community?
- How well characterized (experimentally measured or modeled) is this Composite Part?

To satisfy Competition guidelines, the part must (1) be BioBrick (RFC10) or Type IIS compatible or an agreed exception (on a case-by-case basis), (2) meet the standards set by the Safety & Security Committee, and (3) be documented on the Part's Main Page in the Registry.

Registry documentation should include:

- Basic description of the part
- Sequence and features
- Origin (organism)
- Experimental characterization
- Specific definition of the chassis and genetic context where it was demonstrated to work (and/or where it doesn't work)
- Potential applications
- Appropriate references from the primary literature

The process for judging Basic and Composite parts is almost identical. For both Basic and Composite parts, the teams must follow iGEM standards (ex: RFC10 or Type IIS compatible), demonstrate usefulness of these parts to the wider iGEM community, and provide sufficient characterization and documentation so that future teams may use these parts in their projects. The major difference between Basic and Composite Part evaluation is in how the Part is tested experimentally. Basic Parts by themselves cannot be tested (ex: how would you test a promoter by itself?); they require a test device or other construct in which to be tested. Frequently, Composite Parts can stand alone and be tested, but may also need a test device if the Composite Part is not a full transcriptional unit or similar.

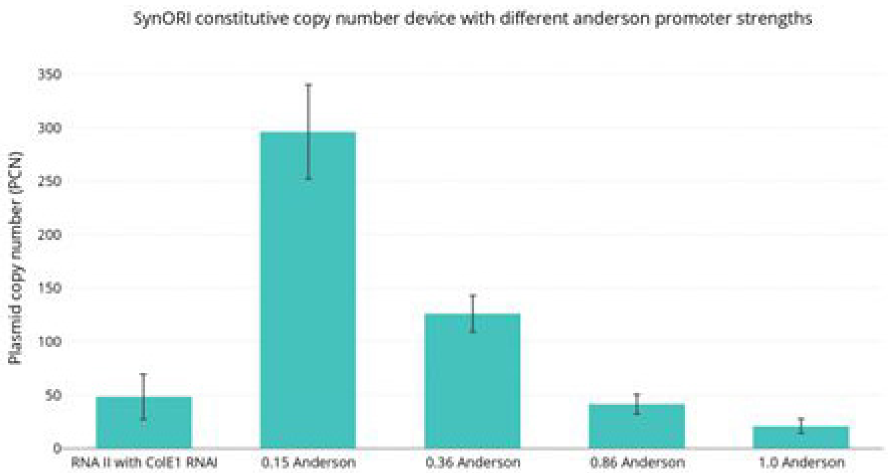
Since the goal of the registry is to be used long-term by scientists and engineers, common issues arise during the process of part documentation. These include:

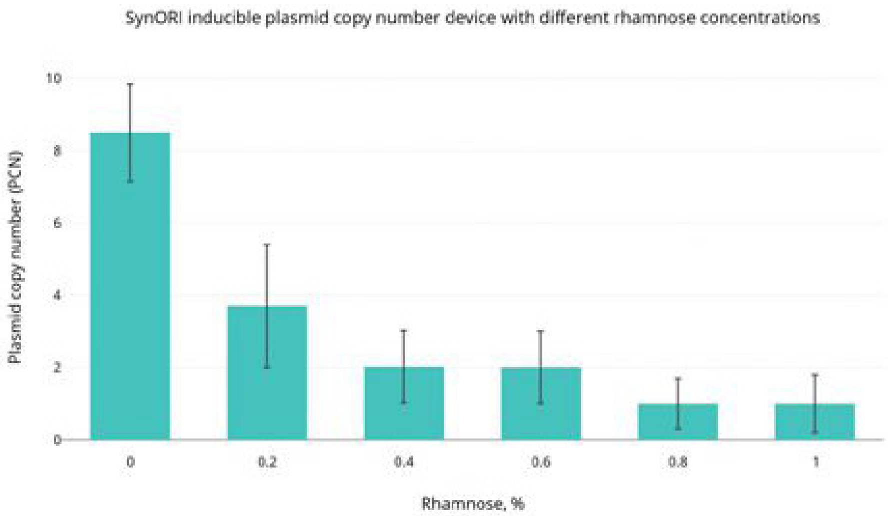
- **Missing experimental details**: Figure axes and legends often lack important details regarding how the data was obtained (e.g., experimental design details, including strain and expression plasmid for protein-coding parts). The data on the Registry page should be able to stand alone; it should be thorough enough to permit verification and replication of the experiments.
- **Missing source sequence**: Lack of literature references or links to UniProt or other databases, which provide the original source sequence for parts derived from natural or *de novo* sources.
- **Missing details for the test device**: Information about which test device, if any, was used on the Registry documentation page (including relevant part numbers for the test device) to generate characterization data for parts. This is most commonly seen for Basic Parts.

New Basic Part Example

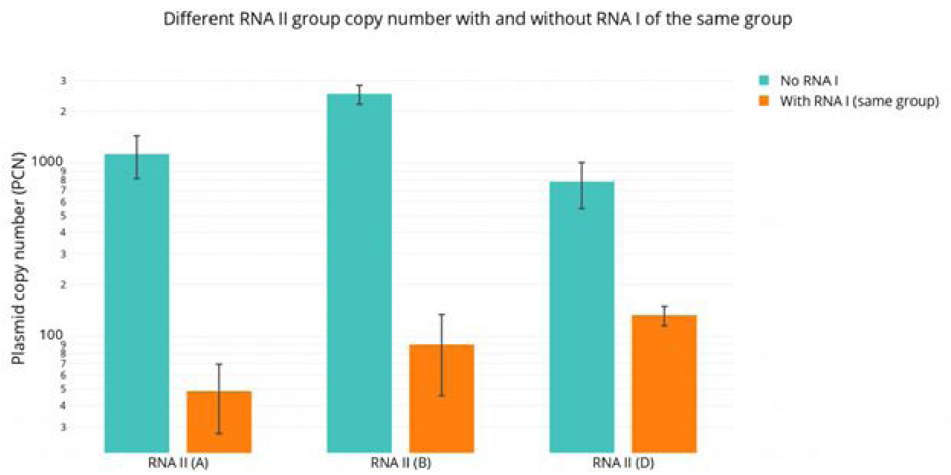
Let's take a look at an example of a Best Basic Part, **BBa_K2259000** (https://parts.igem.org/Part:BBa_K2259000).

This basic part contains RNA II that acts as a plasmid replication initiator and is an essential Biobrick for the framework of a multi-plasmid system which they called SynORI. It was created by the **Vilnius-Lithuania 2017 iGEM team** (http://2017.igem.org/Team:Vilnius-Lithuania). It is also one of the parts in their parts collection that won the **Best Part Collection** in the undergrad section (http://2017.igem.org/Team:Vilnius-Lithuania/Part_Collection). The team has extensively documented their Part on the Parts Registry. They gave an overview of the basic biology of plasmid replication, an explanation of why their part was important and innovative, and a list of references. The team's characterization of the basic part was impressive. First, they looked at the plasmid copy number to see if the RNA II was working, they then used different Anderson promoter strengths and proved that they could control the plasmid copy number in both a constitutive and an inducible manner.

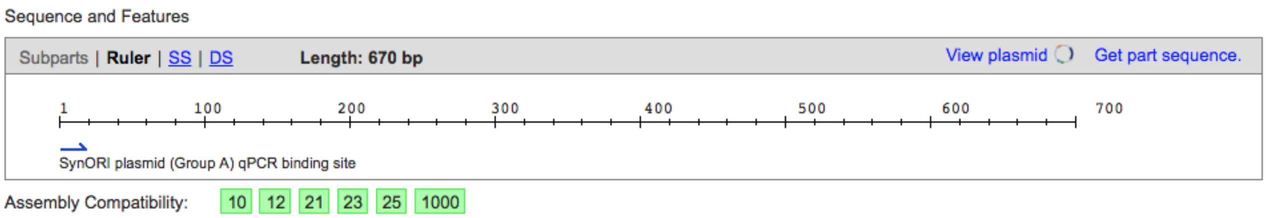




The team has also shown that RNA I works specifically with RNA II along with different groups of their synORI system to control the plasmid copy number as proof of concept.



To satisfy the Registry guidelines, we can clearly see that this part is compatible with RFC10, as there is a green box labeled “10” next to “Assembly Compatibility”. Therefore, this part is accepted in the part status check.



Other examples of Best Basic Parts are:

BBa_K863006 (https://parts.igem.org/Part:BBa_K863006) made by Bielefeld-Germany 2012

BBa_K863001 (https://parts.igem.org/Part:BBa_K863001) made by Bielefeld-Germany 2012

New Composite Parts Examples

The aspects for Composite Parts are the same as for Basic Parts.

Examples for the Best Composite Parts for iGEM 2017 can be found below:

BBa_K2259091 (https://parts.igem.org/Part:BBa_K2259091) made by Vilnius-Lithuania Undergrad Section

Part:BBa_K2306008 (https://parts.igem.org/Part:BBa_K2306008) made by TUDelft Overgrad Section

Part:BBa_K2206006 (https://parts.igem.org/Part:BBa_K2206006) made by CLSB-UK High School Section

New Improved Part

Summary:

- An improved part is a new part that has a significantly improved function over an existing part.
- Experiments to demonstrate the significant improvement must be performed with **both** the existing part (as a control) and the improved part.
- The significant improvement must be documented on the Registry for **both** of the existing and improved part pages.

iGEM encourages the continuous improvement of its Registry of Standard Parts. This prize recognizes the outstanding achievement of a team that improved the design of an existing part in the Registry.

NOTE:

- The sequences of the new and existing parts must be different.
- Adding characterization data to an old part is not sufficient.
- Adapting the part to a different assembly standard does not count as a functional improvement.
- Teams must submit a unique Part for this prize. They cannot submit the same Part for consideration for this prize and either of the New Basic or New Composite Part prizes.

The New Improved Part Prize is judged according to the following aspects:

1. **How does the documentation on the Registry for both the existing and improved parts compare to BBa_K2116002 (existing part) and BBa_K4387000 (improved part)?**
2. **Did the team show that the improved part functions better than the old part (i.e., the old part was used as a control in the testing of the new part)?**
3. **Is it useful to the community?**
4. **How well characterized (experimentally measured or modeled) is this Improved Part?**

Let's look at an example of a new improved part:

UZurich 2022

New Improved Part: **BBa_K4387000** (https://parts.igem.org/Part:BBa_K4387000)

Existing Part: **BBa_K2116002** (https://parts.igem.org/Part:BBa_K2116002)

Although their Wiki also described their efforts to improve an existing part with redesign, all necessary description, data and reference(s) are posted on the Registry for both parts. They thoroughly describe the how and why of their design and the experiments they performed. They tested the parts side-by-side in several different assays and published the experimental results on the Registry pages. They have provided a persuasive and useful record for their improved part.

Part Collection

New in 2025: Document Your Collection in the new Registry

You can now create your Part Collection directly in the new Registry. This feature allows you to provide documentation at the collection level, in addition to the existing documentation at the individual part level.
Collection documentation should describe the collection as a whole: what it does, how the parts work together, and how other teams can use or adapt it.
Part documentation should still be completed for every part in the collection. Each part's Registry page must clearly describe its sequence, function, characterization, and usage. This way, you avoid duplicating text across multiple part pages while still giving judges a clear and focused view of both the system and its components.

What you need to do:

1. Create your Part Collection in the new Registry (https://registry.igem.org/help/how-to-create-a-part-collection)
2. Document the collection itself on the collection page: purpose, design, system-level functionality, and integration.
3. On the Judging Form, provide the identifier of your part collection.

Summary:

- Collections should exemplify a **system** of parts that can be applied to other situations by other teams (e.g., framework for a measurement system).
- The collection of parts should perform a useful or specific function for the community, rather than only be a list of all the parts made by one team.
- A collection must contain at least 3 parts, but there is no upper limit to the number of parts a team can include in a collection.
- A part collection must contain at least three new assembly compatible parts.
- Existing or old parts can be included in a collection.

The most important factor to consider when evaluating the part collection award is how the parts are related. Is it a real collection, or did the team just list all the parts they made in the hope of winning this award? If this is the case, you should disregard the team's entry as the award should only be given to a team who has made a real collection (i.e., a set of parts that together perform a function).

The Part Collection special prize is judged according to the following aspects:

- **Is this collection a coherent group of parts meant to be used as a collection or just a list of all the parts the team made?**
- **How does the documentation compare to the BBa_K747000-095 collection?**
- **Did the team finish building a functional system using this collection?**
- **Is it useful to the community?**

Part Collection Examples

Here are some great examples of Part Collections:

Vilnius-Lithuania 2017

https://2017.igem.org/Team:Vilnius-Lithuania/Part_Collection
The Vilnius-Lithuania 2017 team created a large and extensive part collection in which each piece has a different, specific function. Furthermore, all parts of the collection work for the common purpose of creating a flexible and precise multi-plasmid system. **Part Range: BBa_K2259000 - K2259080**

Arizona State 2016

https://2016.igem.org/Team:Arizona_State/Part_Collection
The Arizona State 2016 team created a part collection that had all of the components to N-acyl homoserine lactone (AHL) quorum sensing system.
Part Range: BBa_K2033000 - K2033011

Thessaloniki-Meta 2022

https://2022.igem.wiki/thessaloniki-meta/part-collection
The Thessaloniki-Meta 2022 team created the Meta-CRISPR part collection as a modular system that allows users to fine-tune the production of the LbuCas13a and crRNA for desired CRISPR applications. **Part Range: BBa_K4170017 - K4170050**

Plant Synthetic Biology

Summary:

- This award is designed to celebrate exemplary work done in plant synthetic biology. It can also be given to a team working with algae or another eukaryotic photosynthetic chassis. This does **not** include bacterial photosynthetic chassis.
- Teams should address a problem or need unique to plant synthetic biology in their work.

Many teams have worked on plant projects in iGEM starting as far back as 2010. Plant teams could tackle a wide variety of projects across many Village themes. As such, we are supporting plants as a Special Prize, rather than as a Village. Teams have created parts from multiple plant chassis and a collections page for plant Parts can be found on the Registry: https://parts.igem.org/Collections/Plants.

The Plant Synthetic Biology Special Prize is judged according to the following aspects:

1. **How successful was the team in engineering a plant, protoplast or algal cell?**
2. **Does their work address a need or problem in plant synthetic biology?**
3. **Did the team create resources/parts/solutions that were suitable for and dependent upon plants/algae to function?**
4. **Are the parts/tools/protocols for plants/algae made during this project useful to other teams?**

Next, let's see how these aspects are applied to example teams:

USP-Brazil 2021

https://2021.igem.org/Team:USP-Brazil

The USP-Brazil 2021 Team was the winner of the Best Plant Synthetic Biology Prize their year. They engineered tomato plants capable of degrading pesticides specifically within the plant's pollen, thereby safeguarding pollinators such as bees from these harmful chemicals. Additionally, they introduced the Micro-Tom (MT) dwarf tomato to the iGEM Competition and compiled a comprehensive handbook of protocols for utilizing this novel plant chassis, aimed at guiding future iGEM teams. Furthermore, they characterized pollen-specific promoters, which hold the potential for application in other plant species.

Navarra-BG 2022

https://2022.igem.wiki/navarra-bg/

The Navarra-BG 2022 High School Team developed tobacco plants to serve as living air sensors capable of detecting high CO_2 concentrations. To achieve this, they characterized a compelling set of CO_2-inducible promoters in tobacco, identifying candidates that could prove invaluable for future iGEM teams. Additionally, they compiled a series of basic protocols for plant work on their wiki, further enriching the resources available to future iGEM participants.

Marburg 2023

https://2023.igem.wiki/marburg/

The Marburg 2023 Team was the winner of the Best Plant Synthetic Biology Prize their year. They aimed to broaden the spectrum of transformable non-model plants. They successfully developed plant transformation protocols for the Bambara groundnut, a non-model crop from Africa. Additionally, they compiled an entire suite of highly accessible plant transformation protocols, well documented on their wiki for the benefit of future iGEM teams. Furthermore, they advanced genetic tools for engineering Agrobacterium, thereby further expanding the array of plant species amenable to genetic engineering.

Bielefeld-CeBiTec 2021

https://2021.igem.org/Team:Bielefeld-CeBiTec

The Bielefeld-CeBiTec 2021 Team focused on engineering tobacco plants to act as sensors for chemical weapons in soil. In this attempt, they introduced the highly accessible Ruby reporter system to the iGEM Competition. This system, notable for its visible red coloration detectable by the naked eye, eliminates the need for specialized equipment. They extensively characterized this reporter system and shared their findings on their wiki. Additionally, in collaboration with iGEM Team Marburg 2021, they co-organized the iGEM Phototrophs community meetups and jointly produced a handbook on phototrophs, furthering their contribution to the iGEM community.

Presentation

Summary:

- The presentation is the chance for a team to tell their story in a concise and visually appealing way.
- Teams prepare video presentations up to 15 minutes long, which will be viewable to judges before the Grand Jamboree.
- Excellent presentation videos are engaging, easily understood by a scientific/engineering community, balance big-picture ideas with design details, and flow smoothly.
- Teams should present their work while thoroughly acknowledging inspiration, background information, prior work and outside support.

Having a successful iGEM project goes beyond the project itself as teams should present their work in a clear and engaging manner, and communicate their project to a scientific/engineering community. Above all, each team should tell a story as they present their work.

There are four aspects for assessment that you should keep in mind as you evaluate presentations:

1. **How well did the team communicate their project goals, design, and results with convincing evidence?**
2. **Does the visual design of the presentation support the communication of the technical content (project design, results and data analysis, and conclusions)?**
3. **Did you find the presentation engaging?**
4. **Were images, prior work, background information, and supporting data acknowledged appropriately?**

Let's look at a few examples of winning presentation videos:

TUDelft 2020

https://2020.igem.org/Team:TUDelft
https://video.igem.org/w/9sU6yxEbYJmkQrqd7sGnTd

Please note that the video length requirement in 2020 was 20 minutes, or 5 minutes longer than the 15 minutes allowed since 2023.

You can watch the TUDelft 2020 presentation video by going to the URL above or by scanning the QR code on the left.

Team TUDelft 2020 produced an excellent example of an iGEM presentation video. The team had multiple student team members present the project in a clear and engaging way. The team started their presentation with a clear explanation of the problem, followed by a description of the pathways they used in their genetic devices with easy-to-follow figures. The team showed how a video can be used to effectively relay a complex project in 20 minutes.

The team did not oversell their project, nor did they use distracting graphics or flashy elements to advertize their work. They clearly and succinctly communicated their project goals, technologies used, experimental designs, modeling and laboratory results, synergistic activities, and future plans.

The team used multiple photographs, text boxes, video clips, and colorful graphics and figures to clearly highlight their work at various stages throughout the presentation. These design elements amplified the team's message and were not distracting. The team clearly described the many technical aspects of their work, as well as the engagement activities, safety risk assessments, and entrepreneurship efforts the team carried out.

In summary, this presentation video was recognized for its excellence in clear science communication, use of various design elements, and audience engagement.

Hamburg 2023

https://2023.igem.wiki/hamburg/index.html
https://video.igem.org/w/7BPoBb7hEvuhHxNGZjfgSY

You can watch the Hamburg 2023 presentation video by going to the URL above or by scanning the QR code on the left.

Overview of the Project:

The Hamburg 2023 Team called their project transFerritin. They modified a ferritin protein to create a drug delivery system. The modified ferritin protein acted like a Trojan horse; it targeted pathogenic bacteria by bypassing the cell membrane while carrying bioactive compounds. Following the engineering design, the team successfully synthesized the modified protein and identified the resulting protein via ion-exchange and size-exclusion chromatographies.

What impressed the judges:

The presentation slides are simple yet effective and informative, as this team used many illustrations of the protein to guide the audience through the project. The team used simple flow charts for the Integrative Human Practice and Education sections and straightforward slides for the project outlook and future works. The clear and simple text throughout the video was easy to understand and complementary to the spoken presentation. Using a thoughtful selection of graphics and good contrast color palettes, the team successfully made the presentation both attractive and clear.

Safety And Security Award

Summary:

- The Safety and Security Award recognizes teams who have done exemplary work to manage risks associated with synthetic biology.
- The best work will make incremental progress towards knowledge, understanding, and tools needed to use synthetic biology to solve real-world problems in a safe and secure manner.
- iGEM takes a broad view of safety and security—projects should reduce the chance that synthetic biology causes any harm, whether that harm might occur through accidental exposure, environmental release, intentional misuse, irresponsible conduct, or any other route.

All iGEM teams must convincingly address the risks in their own project. Teams winning the Safety and Security Award will go beyond showing that their own project was conducted safely by doing safety work with broader application and utility. The winning teams' efforts will create knowledge and/or tools that will help others diminish risk in their own synthetic biology work.

The Safety and Security Award prize is evaluated on the following aspects:

1. **Did the team make a contribution to biosafety and/or biosecurity?**
2. **Is their contribution well-characterized and/or well-validated?**
3. **Did the team build upon existing knowledge, understanding, tools or approaches?**
4. **In addition to broader safety work, has the team managed risks from their own project appropriately?**
5. **Has the team addressed the use of synthetic biology in the real world?**

Let's explore a few examples of exceptional work in Safety from previous years:

NDNF_China 2021

https://2021.igem.org/Team:NDNF_China/Engineering

This high school team created a tool for robust containment: A two-layer hydrogel system designed to allow biosensors or living therapeutics to be used without risk of escape into the environment. The team focused on a real-world problem and built upon existing research into hydrogel-based containment. They validated their work extensively, empirically measuring the material properties of the hydrogel in diverse conditions and the biocontainment efficiency of both a one-layer and two-layer design. The team also managed risks carefully, describing a procedure for carefully managing chemical hazards from acrylamide.

Lethbridge 2017

https://2017.igem.org/Team:Lethbridge/Software

Teams can win this prize by recognizing the potential that their project might be misused and then developing countermeasures to prevent that misuse. The 2017

Lethbridge Team worked on a cell-free engineering platform and designed an orthogonal codon table to reduce the risk of horizontal gene transfer if the system were released into the environment. However, they realized that this same process of genetic recoding could potentially be used to evade DNA synthesis screening. After nine recoding events, a number of hazardous toxin sequences were able to evade a BLAST-based best match completely. The team built software tools to explore the problem space and attempt to decrypt recorded sequences. They also adopted a sensitive approach to information management, working with DNA synthesis companies to disclose the vulnerability ahead of any publication.

Bielefeld-CeBiTec 2018

https://2018.igem.org/Team:Bielefeld-CeBiTec/Public_Engagement

Exemplary work must be empirically rigorous, but does not necessarily need to be focused on a technical advance. The 2018 Bielefeld-CeBiTec team was working on recycling electronics, but realized their system could potentially be used offensively. They also learned that, because their project didn't involve pathogens, it would fall outside most dual-use regulation. They modified their project to minimize its dual-use potential, then conducted a public engagement campaign about dual-use with other iGEM teams. They ran both a national and global survey and designed a series of workshops that iGEM teams could run to learn about dual-use. Teams that ran the workshops were awarded a dual-use awareness badge that they could put on their wikis. Creating the badge immediately incentivized other teams to address dual-use research. The results of the survey and workshop outcomes were eventually written up as a scientific paper.

Software Tool UPDATED

Summary:

iGEM teams often create or adapt software tools to address practical needs in their synthetic biology projects. These tools, whether large or small, can play a crucial role in the success of a project. The **Best Software Tool** prize recognizes computational work that is both **novel and useful**—not just to the team that built it, but to the broader iGEM and synthetic biology community.

An excellent software tool should:

- Aid in wet lab project design or execution.
- Be user-friendly and accessible to non-experts, including other iGEM teams without programming backgrounds.
- Be well-documented and easy to use by generalist judges.
- Be shared publicly under an **OSI (Open Source Initiative)-approved open-source license** (https://opensource.org/licenses).

To be eligible for the award:

- The source code must be submitted via the team's official iGEM GitLab repository.
- Documentation must be clear enough for others to understand, run and adapt the tool.

This award aims to highlight those practical, impactful "nuggets" of computational work that make a real difference. If you, as a judge, do not feel comfortable evaluating the technical aspects of a submission, please contact the **Judging Committee**. They can help ensure the project is evaluated by someone with appropriate software expertise.

The Software Tool award aspects are:

1. How well is the software compatible with, and does it leverage, existing synthetic biology standards (e.g. SBOL, other RFCs, data formats, etc.)?
2. Was this software validated by experimental work?
3. Can the software be useful to other projects?
4. How well can the software be integrated with external tools/software applications (including APIs, packages, etc.)?
5. Is the software user-friendly?
6. How well is the software written and documented for future groups to extend and improve? (This could include code documentation, comments in the code, performance evaluation, architecture diagrams, installation and execution scripts, etc.)

Let's look at examples of great software tools:

Vilnius-Lithuania 2024 NEW

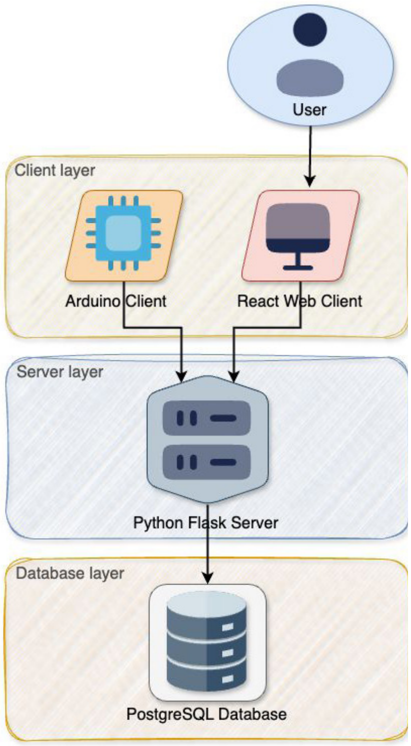
https://2024.igem.wiki/vilnius-lithuania/software

Vilnius-Lithuania 2024 developed a **polysaccharide-based adhesive** inspired by *Caulobacter crescentus* holdfast, aimed at biomedical applications. To support their project, the team created a software tool that complements their innovative hardware—a low-cost, DIY bioreactor—by enabling data collection, visualization, and statistical analysis of experimental results related to adhesion strength.

The tool was created out of a **practical need**—the team required a way to automate and monitor their wet lab culturing process without constant manual intervention. The tool provided real-time insights into parameters like turbidity and temperature, enabling the team to make informed decisions about when to harvest cultures.

The system was designed to be **extensible and integrable with external tools** (Aspect 4). By exposing a documented API and using Docker containers for deployment, the software can interface with other applications or systems, supporting further customization or pipeline integration. But more importantly, they provided clear installation instructions, a recorded demo video to show the tool in action, and a documented API specification. These materials made the tool approachable to others, including users without software development experience. This attention to user support aligns directly with the spirit of the award, which encourages tools that can be used and extended by future teams.

Explore their GitLab repository:
https://gitlab.igem.org/2024/software-tools/vilnius-lithuania



Img: Architecture diagram of the Software Tool by Vilnius-Lithuania 2024.

Fudan 2023 NEW

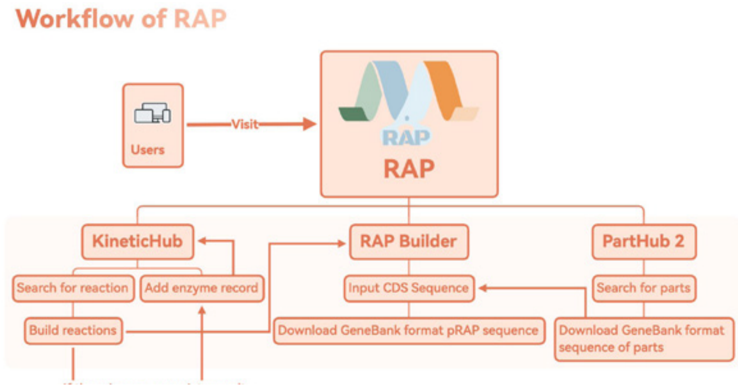
https://2023.igem.wiki/fudan/software

The Fudan 2023 team was awarded the Best Software Tool prize for their development of RAP (Ribozyme-Assisted Polycistronic co-expression), a software suite designed to streamline the design and optimization of synthetic biology constructs. Their project exemplifies best practices in software development, documentation, and integration, within the iGEM community.

The team prioritized user experience by developing an intuitive web interface complemented by detailed tutorials and documentation. They also provided RESTful APIs for advanced users, ensuring flexibility and extensibility. The software's compatibility with GenBank format (Aspect 1) and integration with tools like SnapGene further enhance its utility. This emphasis on user-friendly design and thorough documentation aligns with the judging criteria for **usability** and **documentation**.

The sequences generated by RAP were tested in the lab, confirming the software's practical applicability and reliability. This **validation** (Aspect 2) underscores the importance of demonstrating the real-world effectiveness of the tool.

Explore their GitLab repository: https://gitlab.igem.org/2023/software-tools/fudan



Img: Workflow of the Software Tool by Fudan 2023 team.

Sustainable Development Impact

Summary:

- The Sustainable Development Impact prize is for teams who want to responsibly explore whether synthetic biology could or should be a tool to help reach the UN Sustainable Development Goals (SDGs).
- Successful teams will exemplify iGEMs values, scientific excellence and innovative potential in reaching one or any coherent set of SDGs.
- Being successful with regard to the Sustainable Development Impact prize is built on top of success in other areas of iGEMs judging, particularly Human Practices.
- Since the SDGs are built on a holistic understanding of what it takes to solve today's grand societal challenges. Successful teams must display an understanding and respect for the interconnectedness of the social, economic and environmental dimensions their work is committed to help solve.
- A successful team project will show a continuous commitment to the social, economic and environmental aspects of their project, which can be demonstrated in a team's active engagement with multiple stakeholders, and an openness and responsiveness to what that engagement produces- even if that engagement does not support their efforts.

The focus of this prize is on iGEM's responsibility to participate in figuring out how the world can meet the SDGs, while exploiting iGEM's enormous innovation potential to do so. It provides teams a mechanism to participate in global conversations while developing solutions towards meeting the SDGs. In so doing, it instructs teams on the necessity of taking a transdisciplinary approach, i.e., approaches that use resources from multiple disciplinary perspectives, as well as from ones outside of academia (including for instance policy, civil society or business).

The Sustainable Development Impact special prize is judged according to the following aspects:

1. **Did the team incorporate feedback from relevant SDG stakeholders into their work?**
2. **Did the team address potential long-term social, environmental and economic impacts of their work (in the context of the SDG(s) they have chosen)?**

3. **How well has the team considered the positive and/or negative interactions of their work with other SDGs?**
4. **Has the team documented their work against their chosen SDG(s) so that other teams can build upon their work?**
5. **Has their work measurably and significantly addressed one or more SDGs?**

We encourage judges to access the UN SDG Partnership Platform (https://sdgs.un.org/partnerships/browse), where you can search for current and past projects from across the globe addressing the SDGs. You can search by a specific SDG goal. Clicking on any project will provide an example of the frameworks and information we are expecting iGEM teams to include in their projects. And just like iGEM projects, the projects listed in the UN platform vary in detail and quality.

Next are examples of past iGEM teams who won this prize:

Fudan 2020

https://2020.igem.org/Team:Fudan/Sustainable

The Fudan 2020 team explored three SDGs in their work on creating a sustainable calcium supplement to help people suffering from osteoporosis: SDG 4 Quality Education, SDG 9: Industry, Innovation and Infrastructure, and SDG 3 Good Health and Well-being.

This team worked to identify the long-term social, economic, and environmental implications of seniors suffering from osteoporosis. With SDG 4 in mind, the team attempted to further interest seniors in the topic of bone health through an online audio course they produced. They also ran a two-day online Summer camp to connect with high school students about biotechnology used in synthetic biology. For SDG 9, team Fudan used social media and podcast platforms to create an inclusive and sustainable community of listeners for their online course. Finally, the team visited seniors, combining performance art with education and promotion of physical activities targeted to seniors, with the aim of promoting healthy lives and well-being (SDG 3).

Calgary 2022

https://2022.igem.wiki/calgary/sustainable

The Calgary 2022 team designed a product called Cellucoat, which is a sustainable and antimicrobial packaging material for fruit. Cellucoat would extend the shelf-life of fruit and replace conventional plastic packaging. They identified four SDGs that related to their technology. Within each SDG, they described several smaller local problems that needed to be addressed. They discussed how their technology could alleviate each problem and also which limitations they might encounter. They provided stakeholder feedback relevant to each SDG. Beyond simply naming relevant SDGs, their documentation revealed a thorough, thoughtful and comprehensive consideration of the issues that were supported by productive dialogue.

Wiki

Summary:

- The wiki is meant to be the primary permanent record of a team's project, including a description of who did which parts of the project.
- A great wiki will be visually appealing, concise, and easily navigable.
- All project details should be included, but it should be clear where to find the key information.

In iGEM, the purpose of the team wiki is to publicly provide full project details to future teams, researchers and the general public, in an organized, visually appealing manner. These details can and should include everything needed to reconstruct the project from the ground up, including the project goals, background information, research strategies, a lab notebook, experimental results, protocols, model documentation, results, safety information, BioBrick parts made, etc. Furthermore, wikis must meet the wiki requirements listed on the iGEM website (https://competition.igem.org/deliverables/team-wiki), such as assuring that all content is hosted on iGEM servers and that Creative Commons Attribution is displayed on the footer of every page.

The wiki is the very first thing a judge sees when assessing one of their assigned teams since the wiki evaluation occurs before the Grand Jamboree begins. Characteristics like whether or not a wiki is informational, easy to navigate, or visually appealing can make a big impact on a team's critical first impression to the judges. There are five aspects for wiki assessment that you should keep in mind as you explore the team's wiki:

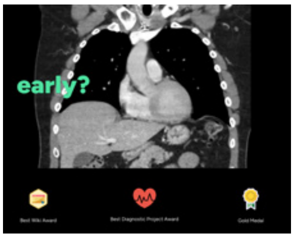
1. **How well does the wiki communicate the team's project and their goals?**
2. **Did the team clearly document their project and support their results with convincing experimental evidence?**
3. **Does the design of the Wiki support visitors in finding and understanding the content?**
4. **Will the wiki be a compelling record of the team's project for future teams?**
5. **Is the content (including text, images, and prior work from iGEM teams and other research groups) on the wiki properly referenced and cited?**

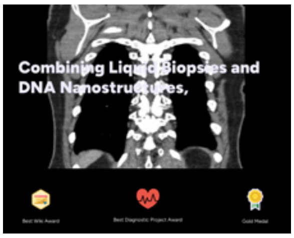
Let's look a few examples of winning team wikis:

Patras_Medicine 2022

https://2022.igem.wiki/patras-medicine/

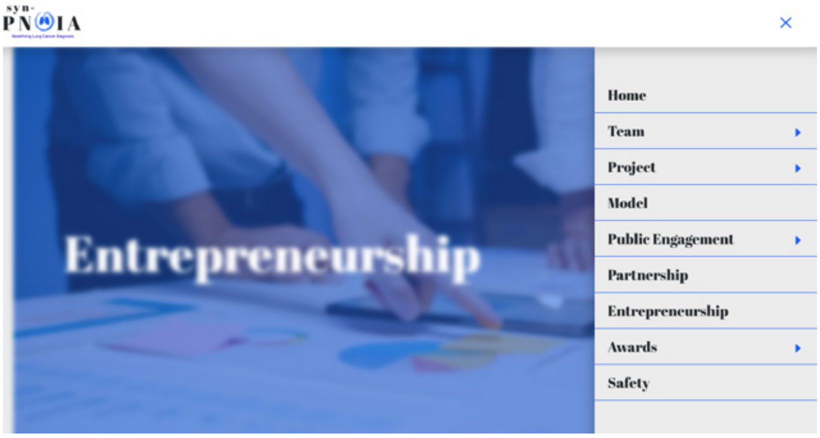
As we enter the wiki for Syn-Pnoia, we see an animated visual of a scan for lung cancer with text describing the motivation behind their project: using synthetic biology to develop a more effective early diagnostic method for lung cancer. The Patras_Medicine 2022 home page delivered a succinct description of their project work, the synthetic biology tools utilized to develop their diagnostic approach, and key facts about lung cancer and how earlier diagnosis would lead to increased survivability.



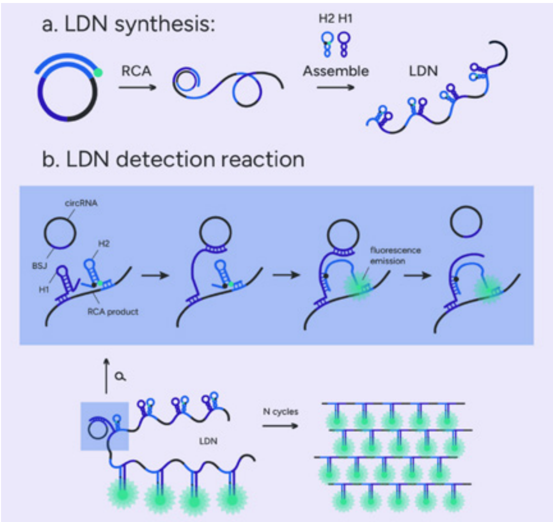


At the base of their main page, they redirect the reader to various aspects of their work: wet lab; product design; integrated human practices; education and communication of their project both locally and globally; and the model used to design their product.

Their wiki stood out to the judges due to its ease of navigation. From the side menu, the judges could access key information about their project in relation to the criteria they had to evaluate, allowing for ease of referencing different pages during judging.

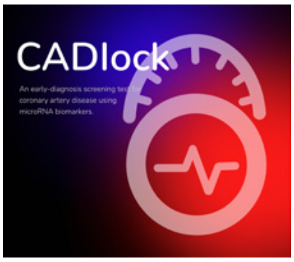


The team was methodical in their approach to building the wiki, and this organization allows for an easy and understandable flow of the project from page to page. With clear figures describing their procedural goals step-by-step, they were able to enhance the understanding of the projects to audiences that were not familiar with the techniques that they used.



Additional care was put into the wiki to attach associated videos, protocols, and information relevant to the figure or experiment they were describing, while keeping all of that information hosted on the iGEM server.

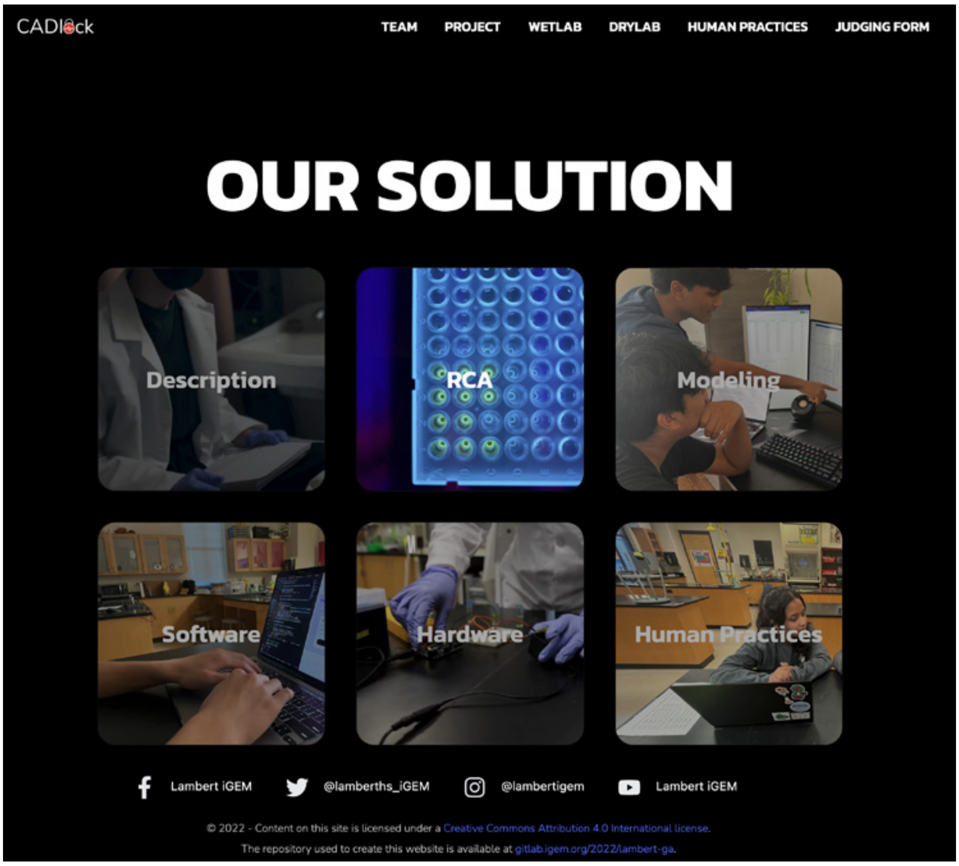
Overall, this wiki serves as a great organizational model for future teams, while also integrating an aesthetically pleasing color palette that is clear and visually accessible.



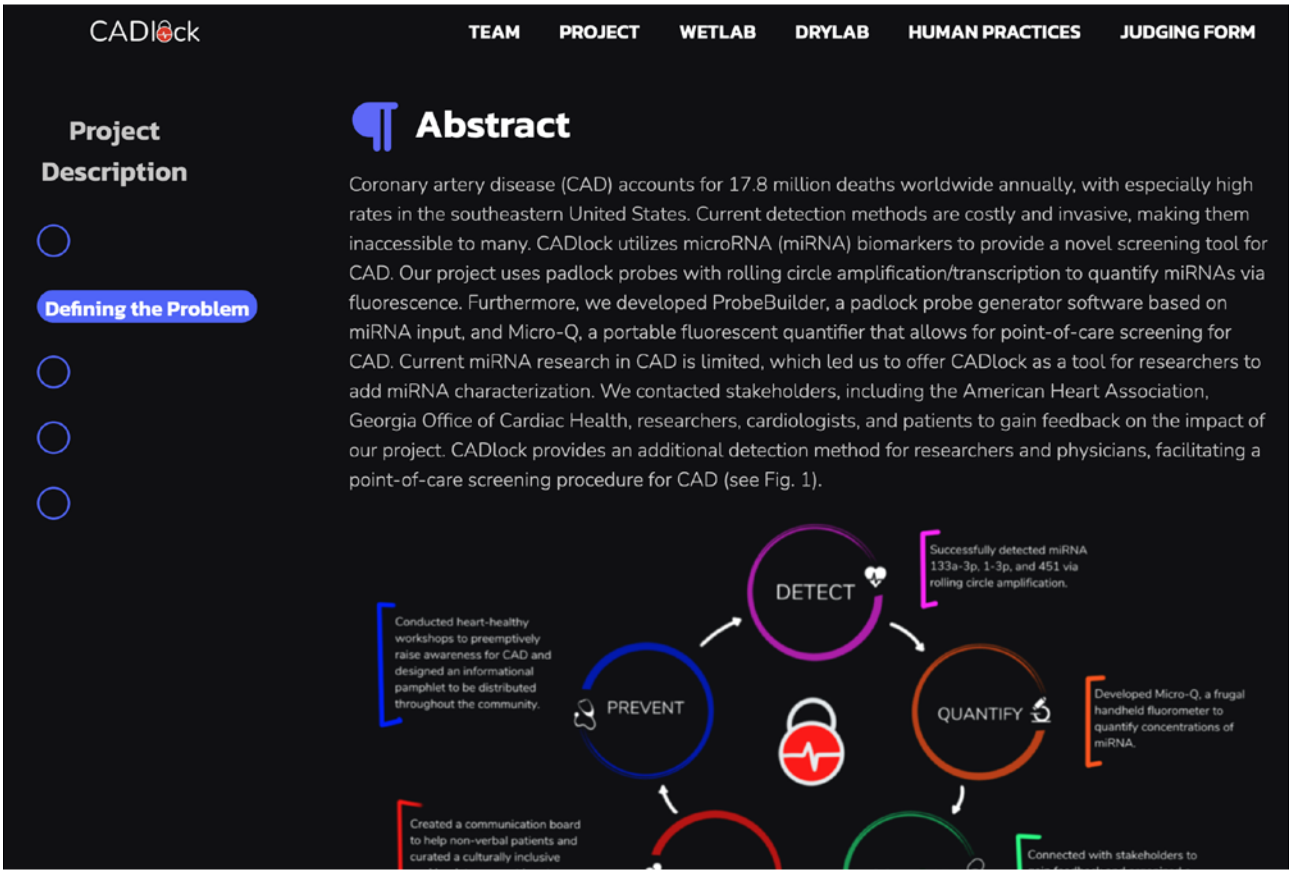
Lambert_GA 2022

https://2022.igem.wiki/lambert-ga/index.html

The wiki of Lambert_GA effectively communicates the team's project and goals through a comprehensive introduction, clear objectives, detailed methodologies and solid evidence. If we start from their homepage, we can see a very concise and clear concept of their product "CADlock". Scrolling down, they use one sentence with one schematic each to briefly introduce the background of the coronary artery disease and basic design of CADlock. If we keep scrolling down, a clear guidance of different sessions of their solutions appears.



Clicking on "description", we can see a clear and detailed description of their project design divided into: abstract, defining the problem, microRNA background, our approach, and references. Usually, description is the first session people review to learn about the project. Their wiki seems to have done a good job of providing a comprehensive overview of their project and its goals.



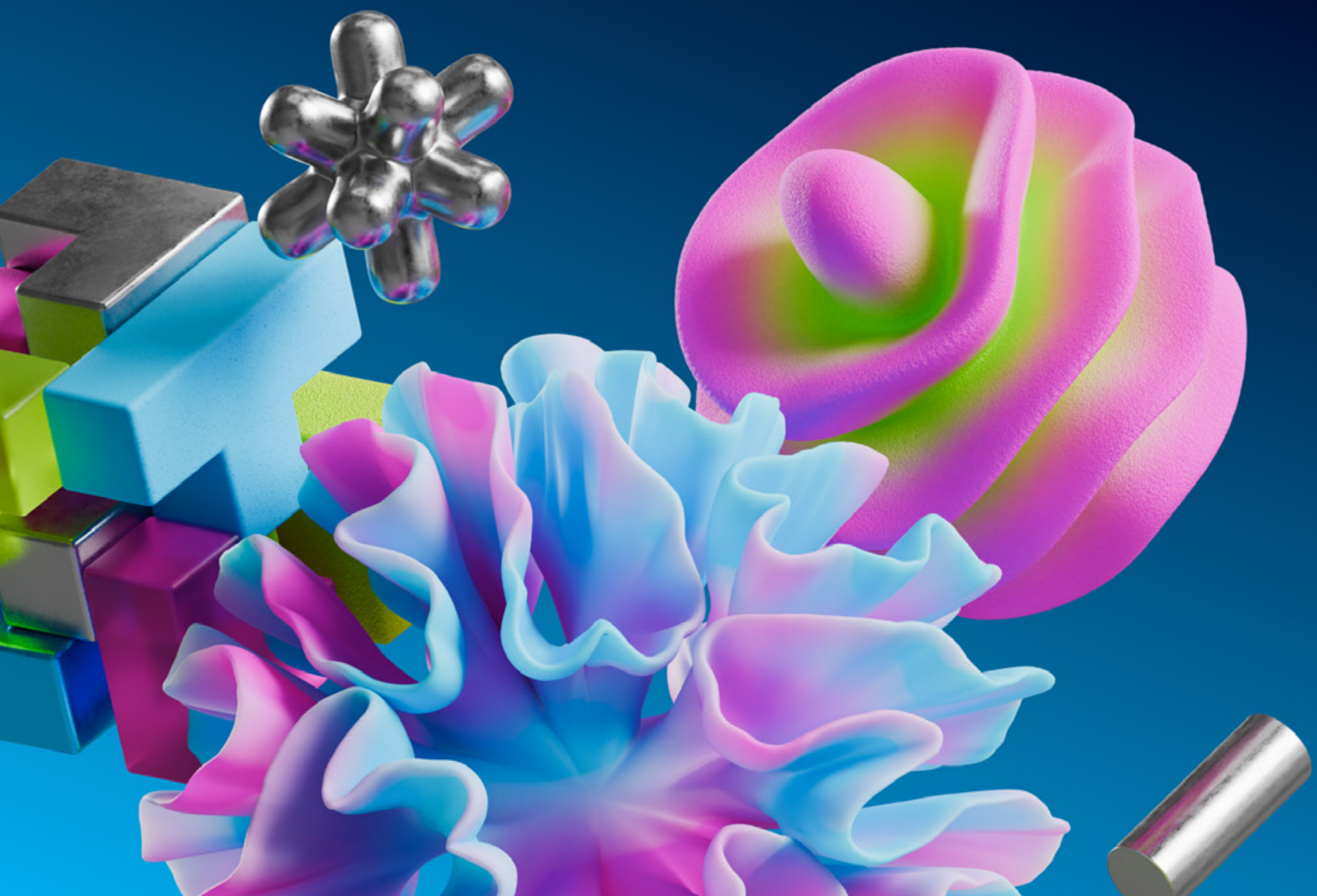
The wiki is well designed, functional, and easy to navigate. The team has organized their wiki into sections, including: team, project, wetlab, drylab, human practices, and judging form. Each section has clear headings and subheadings, making it easy for readers to find the information they need. The wiki's design is visually appealing, with a clear and easy-to-read font, and well-structured paragraphs and sections.

Lambert_GA has provided detailed documentation of their project, including the experimental setup, protocols and data analysis. They have also included graphs, charts, and images to support their findings. The team has demonstrated that they have carried out rigorous experiments to validate their project's efficacy, as evidenced by their well-documented results section. The team also explains their findings and results with clear and concise language, which makes it easy for readers to understand their findings.

Overall, Lambert_GA's wiki will be a compelling record of their project for future teams. The team has provided comprehensive documentation of their project, including detailed methods, results, and analysis. Their wiki provides an excellent resource for anyone interested in learning about their project, as it is easy to navigate, well-structured, and visually appealing. The team has also provided extensive references and resources, which future teams can use to build upon their work. The team's wiki provides a valuable contribution to the iGEM community and serves as a solid foundation for future projects.

CHAPTER 5

iGEM High School Competition



Introduction

Summary:

- Starting in 2025, High School teams compete in the newly launched iGEM High School Competition.
- Starting in 2025, each High School team will choose their own Village and will display their projects alongside collegiate teams in the shared Village spaces during the Grand Jamboree.
- Starting in 2025, High School teams must ensure that their projects use only the organisms and components specified in the current iGEM White List. Additionally, all team activities must strictly align with the items included in the White List. More information is available at: https://responsibility.igem.org/guidance/white-list
- In the judging ballot, you should judge High School teams *just as you would a standard collegiate team*, but keep in mind the following:
  - High school students are often still deciding whether or not to pursue a career in science/engineering.
  - As a judge, your interactions with them could have a significant effect on their future career.
  - *You should mark the ballot according to the language scale, but in your comments and discussions with the teams, remember the potential impact of your words!*

When judging high school teams, please keep in mind that many high school teams must deal with additional factors such as a smaller budget, lower availability of laboratory facilities, shorter working hours, and perhaps the lack of college-level courses so far in their education. As a result, it can be considered a substantial achievement for a high school team to make a functioning Part.

Despite potential challenges, high school teams are capable of making interesting and significant contributions to synthetic biology. In fact, it can be difficult to distinguish between the best high school teams and many collegiate teams.

One example of a high school team is GreatBay_SZ 2019. It is described on page 32.

Let's look at another example of a winning High School team.

TAS Taipei 2017

http://2017.igem.org/Team:TAS_Taipei

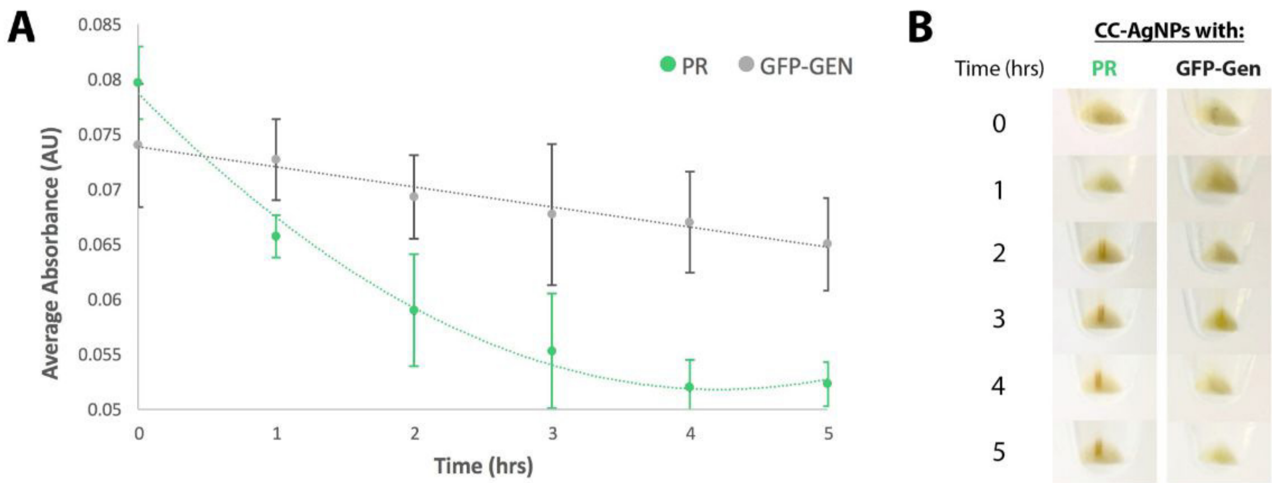
In 2017, the team TAS Taipei (http://2017.igem.org/Team:TAS_Taipei) impressed the judges with their project, Nanotrap: Nanoparticle Removal from Wastewater Systems. They not only won the High School Grand Prize trophy, but they were also awarded Best Wiki and were nominated for Best Presentation, Best Poster, Best Integrated Human Practices, and Best Part Collection.

TAS Taipei's project revolves around nanoparticles, common additives in consumer products, including sunscreens, makeup, and athletic clothing. Due to the pervasiveness of nanoparticles in products, it is estimated that several hundred tons of nanoparticles are entering our wastewater each year, potentially causing significant negative environmental and health effects.

The team took a two-pronged approach in their solution to remove nanoparticles from wastewater:

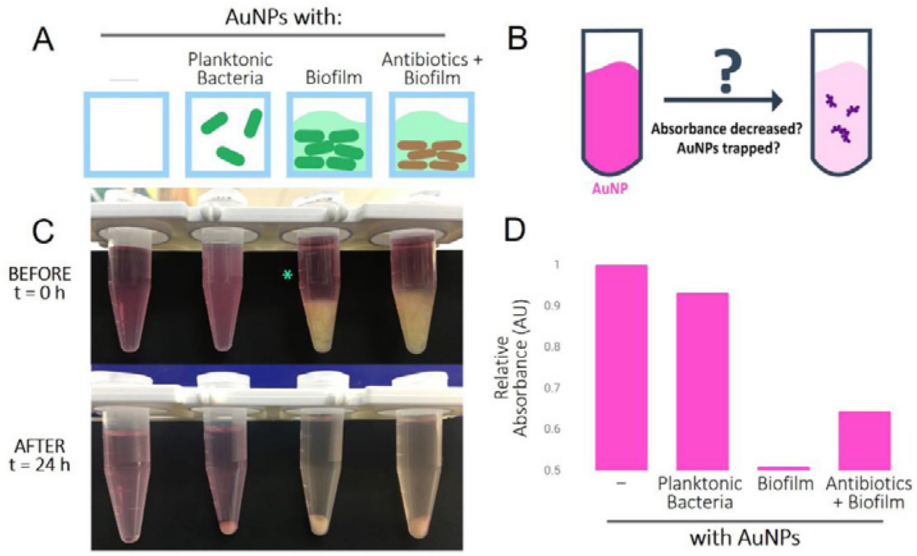
1. Proteorhodopsin receptors (PR) to bind citrate, a common capping agent in nanoparticle synthesis
2. Production of biofilms in *E. coli* to capture the nanoparticles not capped with citrate

For the first part of their project, they designed a part to express a PR in *E. coli*. They then tested their modified bacteria to see if they could trap citrate-capped nanoparticles (see figure).

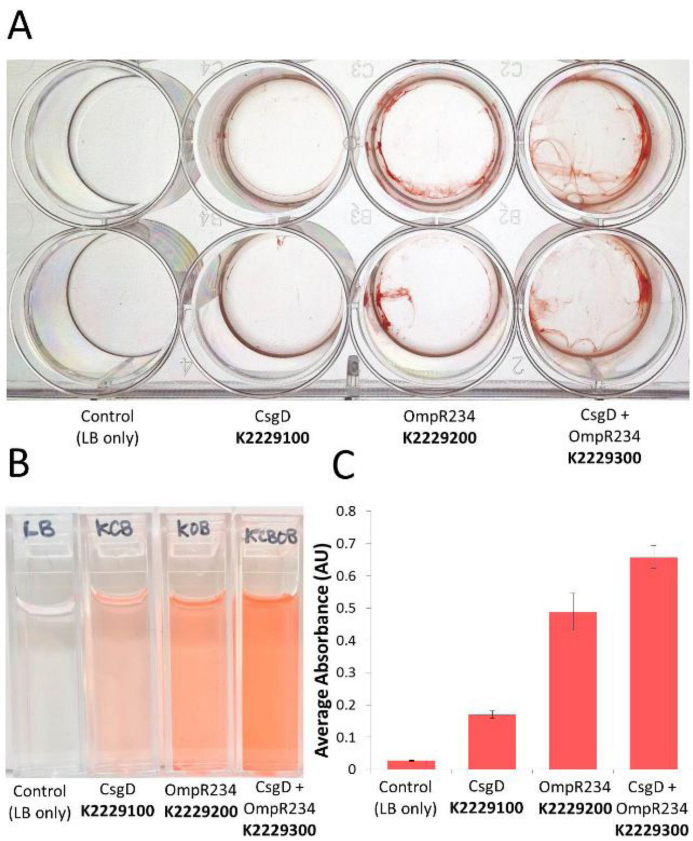


As seen in their experimental results, the strain containing PR shows a decrease in absorption relating to nanoparticle presence over time, and the cell pellets show an increased dark mark corresponding to nanoparticle collection. It is clear that this part works to bind nanoparticles from solution.

For the second part of their project, the team first attempted a proof of concept study to see if biofilms could trap nanoparticles. As seen in the second figure, they saw a decrease in absorbance corresponding to nanoparticle presence when biofilms were present (even when the biofilms were treated with antibiotics to kill the living cells).

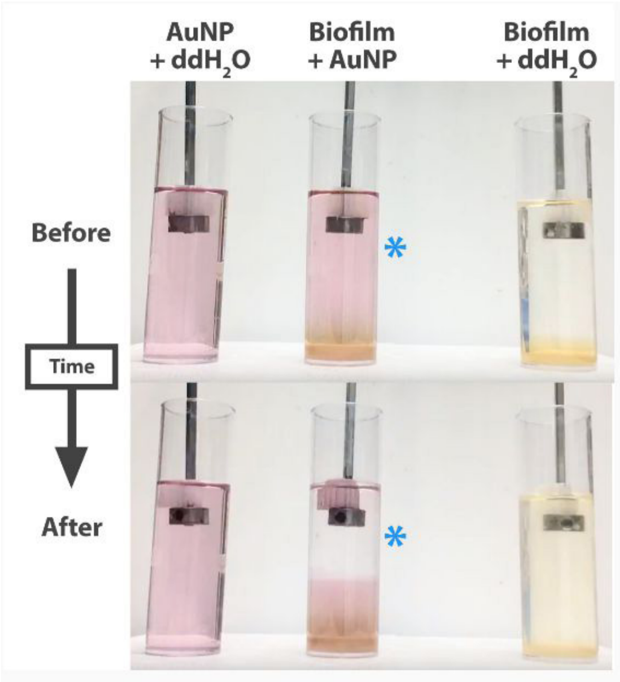


After verifying their idea, the team's next step was to design parts in *E. coli* that would enhance biofilm production. They decided to overexpress the *curli* operon using two different genes, *csgD* and *ompR234*. When expressed, these genes both successfully increased biofilm production, and the combination of the two increased biofilm production to an even greater extent (see third figure).



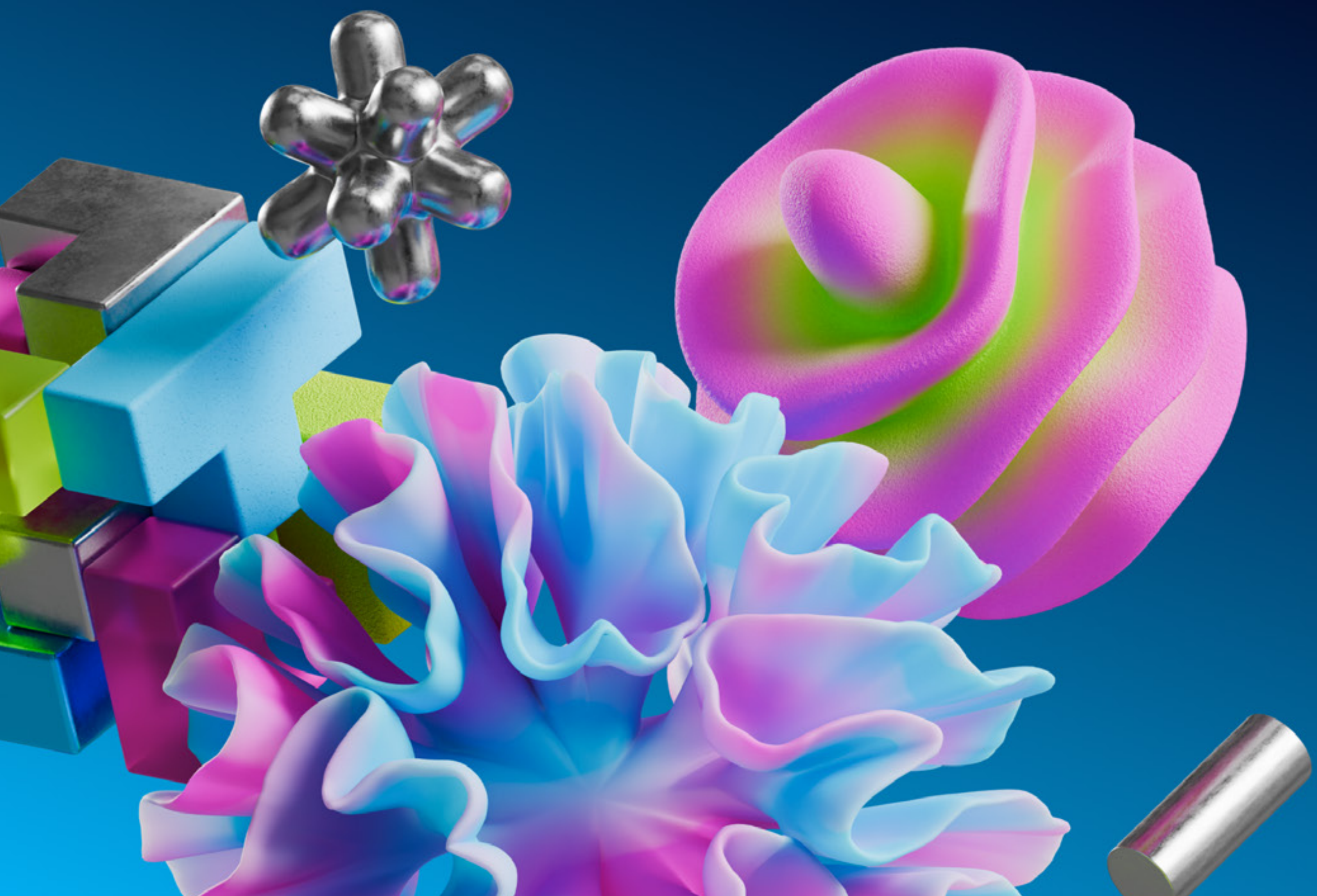
Even after showing that their parts worked fairly effectively, the team took it a step further by modeling their system and using that model to estimate the kinetic parameters of binding/cell trapping, and then creating a calculator tool to estimate how much of their *E. coli* you would need to treat a certain amount of nanoparticles.

Finally, the team did work to see how well their system would work in a real wastewater treatment-style setup. They found initially that current styles of wastewater treatment would not be sufficient for trapping nanoparticles, but by making a few simple changes, such as the addition of a biofilm "carrier", their biofilm-creating *E. coli* could be adapted for sedimentation tanks.



TAS Taipei demonstrated an impressive number of accomplishments, and did so with a high level of engineering design and scientific quality, as seen by their use of controls, proof-of-concept experiments, and prototyping. Furthermore, the project clearly works and, as seen in the figure captions throughout the wiki and on the attributions page, the students themselves likely did most of the work. Even though the parts themselves are not necessarily complicated or creative (only the proteorhodopsin receptor gene was new to the Registry), the project is definitely based on synthetic biology and standard parts, and the parts they used are well-documented in the Registry. In their discussion of how to apply their project to real wastewater treatment, they were clearly thoughtful with regards to Human Practices, and it is possible that the project could have an impact, since microbes are already a significant part of the wastewater treatment process. In summary, TAS Taipei 2017 is an excellent example of a top-notch High School iGEM project.

Acknowledgements



Acknowledgements

We are excited to present this Handbook to the judges and hope that it will be a valuable reference for both veteran and new judges alike. This resource would not have been possible without the help of our many contributors, the number which grows each year. Since the handbook was first published in 2012, dozens of talented people have volunteered their time and effort producing, reviewing and improving it. We would like to thank everyone who has contributed their talents to the production of this handbook.

We also want to thank the Human Practices, Engineering, Safety and Security, and Responsible Conduct Committees for the countless hours they have worked to make iGEM great each year. We have so many wonderful people who help out on our committees throughout the year and we are incredibly thankful for their contributions.

Finally, and most importantly, **we want to thank you** for volunteering your time to serve as a judge for the 2025 iGEM Grand Jamboree! Through the judging program, you are actively helping and guiding the next generation of synthetic biologists. Thank you so much for your time and effort! We appreciate everything that you do for iGEMers and hope you enjoy the experience!

We hope to see you back as a judge for 2026!

With sincere thanks,

The Judging Committee and iGEM Headquarters