iGEM

2021

JUDGING HANDBOOK

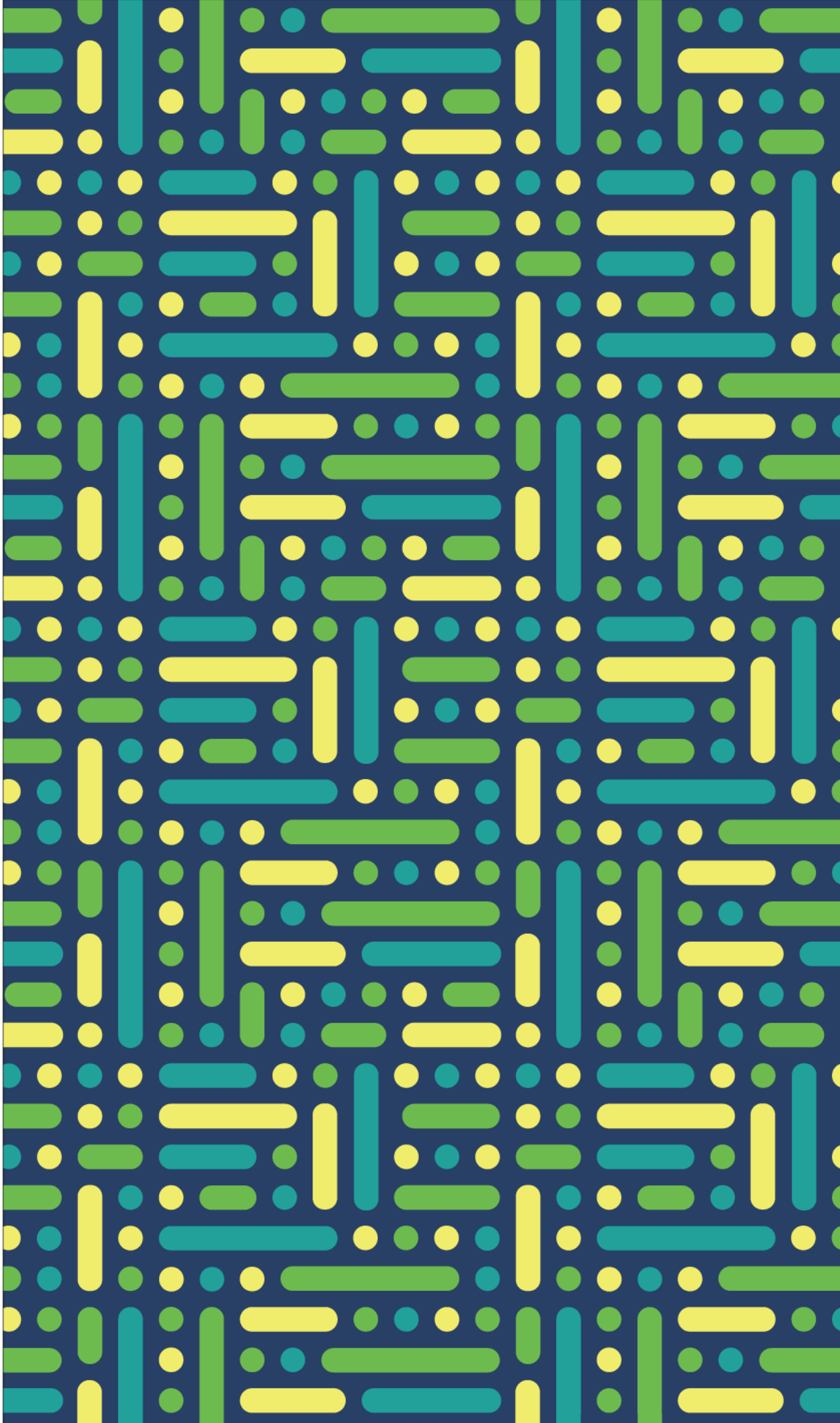

Table of Contents

New Updated

CHAPTER 1

Introduction to Judging

Introduction from the Director of Judging

Coming soon!

The 2021 iGEM Judging Committees

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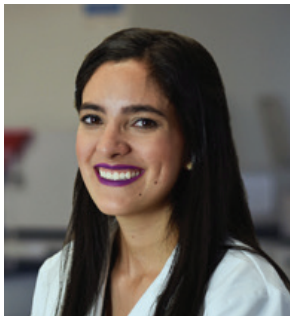

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How to Use this Handbook

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 Handbook contains information about all the areas that you may need to evaluate.

As you will likely not be assigned teams from all the tracks described or need to evaluate every special prize, we don't recommend reading this book from cover to cover. We suggest you use this Handbook to learn how we value excellence (see past finalists, starting on page 21) and as a reference manual if you need information on a specific area, such as the Special Prizes (see Chapter 4, starting on page 45) and High School teams (see Chapter 5, starting on page 89).

All judges must read Chapters 1 and 3, as those chapters explain the judging process, include any major changes to the process, and go over medals, which impacts every team.

This book contains a lot of detailed information and while we have done our best to make it as easy to understand as possible, you may still have some questions. There will be more ways to get up to speed on judging before the Jamboree, but if you would like information now, please email *judging [AT] igem [DOT]* org with "Judging Handbook Questions" in the subject line.

Questions?

For questions, please email us at: **judging@igem.org**

Special Note for 2021

This handbook has been available for our judges and teams for many years and we update it annually. For 2020 and 2021, COVID-19 may have dramatically affected what teams could achieve, particularly in the lab. Some teams may continue to have no lab access at all, while others may have limited or full access. With these possible lab limitations in mind, the medal criteria was changed in 2020 to ensure that teams without lab access could achieve any of the medals. We have kept those changes in place for 2021. You can read more about these changes in Chapter 3: Medals.

Thank you for volunteering to judge and from the Judging Program Committee and Judging Corps Committee, we hope you enjoy iGEM this year!

How to Begin Your Judging Assignment

When you begin your assignment, you will navigate to your Judge Dashboard, where you can easily access the team judging ballots to evaluate your assigned teams based on the 3 prize categories: **Medals, Project,** and **Special Prizes**.

Step 1: Evaluate for Medals

When using the judging ballot, the first thing you should do is evaluate the team for their medal (see the "Medals" chapter on page 37 of this handbook for more details). ***When evaluating a team, ask yourself if the team has convinced you that they have met the criteria***. If you feel the team has merely "checked a box" stating they have met one of the medal criteria, but you feel they have not achieved enough to warrant the medal, you can choose not to award that medal. A similar philosophy should be used for all of the rubric aspects in iGEM.

Step 2: Evaluate the Project Sections

Once you have decided on which medal, if any, to award the team, you can move on to evaluating the rest of the judging ballot for the team. The "Project" section of the ballot is used to determine where the team will rank in their track and how they will stack up compared to all other teams in the competition (i.e., whether they will be finalists). This category is one of the most important, and it should reflect the team's achievements as a whole.

Step 3: Evaluate the Wiki, Presentation, and Other Sections

After evaluating the "Project" section, you will move on to evaluate the team's Wiki, Presentation, and any other open sections in the ballot which will identify which special prizes the team is competing for. In most cases, the special prize will directly link to a page on the team wiki with information about what the team has achieved to warrant winning that award. *If a team has not used the required standard wiki page for that special prize, they are not eligible for that prize.*

This measure is intended to encourage teams to be clear about what awards they are competing for and for judges to easily find this important information. Time should be spent evaluating wikis, not searching them for content. For more information on this topic, see the **Pages for Awards** (https://2021.igem.org/Judging/Pages_for_Awards) on the iGEM website and Standard Pages for Awards on page 47.

Step 4: Vote on the Winners!

Finally, the highest ranking teams as determined by the “Project”, “Wiki”, and “Presentation” sections will become Finalists and will be announced on Tuesday, November 9. The last act of being a judge at iGEM is to view the Finalists’ presentation videos following this announcement, review their team Wikis, and then vote on which team will win the coveted BioBrick trophy. Voting will take place during the final judges meeting on Saturday, November 13, which is scheduled to take place between 9:00-11:00 AM EST.

Points to Consider During Your Evaluations

On Judging Sessions

The switch to video presentations has offered a new opportunity for team-judge interactions during the Virtual Giant Jamboree. Last year, we introduced Judging Sessions: a 25-minute discussion session between the teams and their judges, where each team was given 5 minutes to present their project followed by 20 minutes of questions and discussion with their judges. We will continue to hold these Judging Sessions this year. Judges will use this time to ask their assigned teams questions and engage in discussion about the teams' projects. The goal for these sessions is to provide a more lengthy contact time between the teams and the judges, while also allowing the public to view and possibly participate in these sessions.

Although you may experience some communication issues if you and the students speak different native languages, you should be able to distinguish between communication problems and a lack of knowledge of the project.

Prior to the Judging Sessions

Judges, you must watch the team presentation video and read the team wiki before the scheduled Judging Session with your assigned teams. Your Judging Sessions will be scheduled so you will have 3 teams back-to-back, so you must watch and read the materials for those 3 teams prior to the start of the Judging Session. As you watch the presentation video and read the wiki pages, you should take notes and come prepared to the Judging Sessions with your questions and comments ready.

On Written Feedback

Teams care about getting feedback from judges. Many teams will win awards, but most will not, simply because we do not have an award for every team (medals are a different story). This makes written feedback from the judges an important part of the competition for students. Teams will receive two types of feedback from iGEM: a summary of their scores and written comments from the judges. Any votes you cast will be summarized and anonymized and provided to the teams. Your written comments will be aggregated, anonymized, and displayed on the same page as scores.

Judges are required **to provide two types of written feedback on the judging ballot page for each of their assigned teams: positive feedback and constructive criticism.** Written comments are incredibly important to teams, so please make sure you set aside time to provide useful feedback to each of your teams. We will release the feedback to teams within two weeks after the Awards Ceremony.

Some questions to help guide you for writing this feedback include: What was your favorite part of their work? What area was the most impressive part of their project? Is there an area in which you can provide guidance so they can improve the work? Is there a useful future application of this work? Do you have any comments about work they submitted for the medal criteria?

Remember: English is a second language for most iGEM teams. For those teams, being able to view written comments and translate them back into their native language allows them to understand your feedback and learn from you.

As an iGEM Judge, you are expected to provide substantial written feedback to each of your assigned teams. A single sentence is not useful and is considered inadequate feedback, as are short statements such as "Good job!". Without more context about what they did well, simply saying "Good job!" is not a helpful comment. These teams have put hundreds of hours of work over many months into their projects and we ask you to provide well thought-out comments to reflect their efforts. The teams want to learn from your experience, guidance, and feedback, so please provide them with useful comments and suggestions that they can learn from and use to improve future work.

The discussions that will take place during the judging sessions are not a replacement for written feedback.

We cannot over-state this: written comments are very valuable to the iGEM students. **Providing good, useful written feedback is one of your responsibilities as an iGEM Judge.**

Remember you will mostly be addressing undergraduate students and, in some cases, high school students. The tone of your feedback could have an effect on their future career choice, so please choose your words wisely with this fact in mind.

On Safety

iGEM expects all teams to demonstrate to iGEM HQ, the wider community, and to anyone interested how they are working safely and securely. Teams do this by thinking carefully about and managing any risks to themselves, their colleagues, their community, or the environment.

We expect everyone involved with iGEM to act responsibly throughout the competition. Please read our **Roles page** (https://2021.igem.org/Safety/Roles) for more information on the roles and responsibilities of team members, instructors, and what you can expect from iGEM's Safety and Security Committee.

iGEM has clearly communicated the **Safety Rules** (https://2021.igem.org/Safety#rules) and **Policies** (https://2021.igem.org/Safety/Policies) that every team must follow. Each team has submitted a final Safety Form, which has been reviewed by the Safety Committee. Anyone can review these Safety Forms here: https://2021.igem.org/Safety/Final_Safety_Form.

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

iGEM has a series of values that we take seriously. Integrity, good sportsmanship, respect, honesty, celebration, cooperation, effort, and excellence are some of the values that we place in high regard for all participants. iGEM students, advisers, instructors, and judges are almost always exemplary in their conduct and behavior.

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

Please see our **Responsible Conduct Page** (https://2021.igem.org/Competition/Rules_of_Conduct/Responsible_Conduct) for more information including hypothetical case studies.

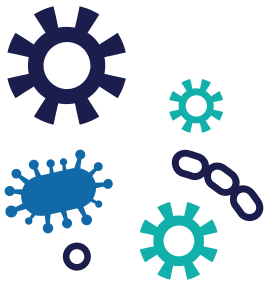
? Questions or Concerns?

If you think a case of misconduct requires investigation, or if you have questions, please email us at: *rcc@igem.org*

On Attribution

We care about teams telling us what they did and where their ideas originated. Each team must clearly attribute work done by the student team members on their team wiki. The team must distinguish work done by the students from work done by others, including the host labs, advisors, instructors, and individuals not on the team roster. This requirement is not about literature references - those can and should be displayed throughout the teams' wikis.

The Project Attributions page is one of the required Standard Pages for the 2021 team wiki pages. You will find that this page already exists on the team wikis at the following URL: **https://2021.igem.org/Team:Example2/Attributions**.



On Engineering

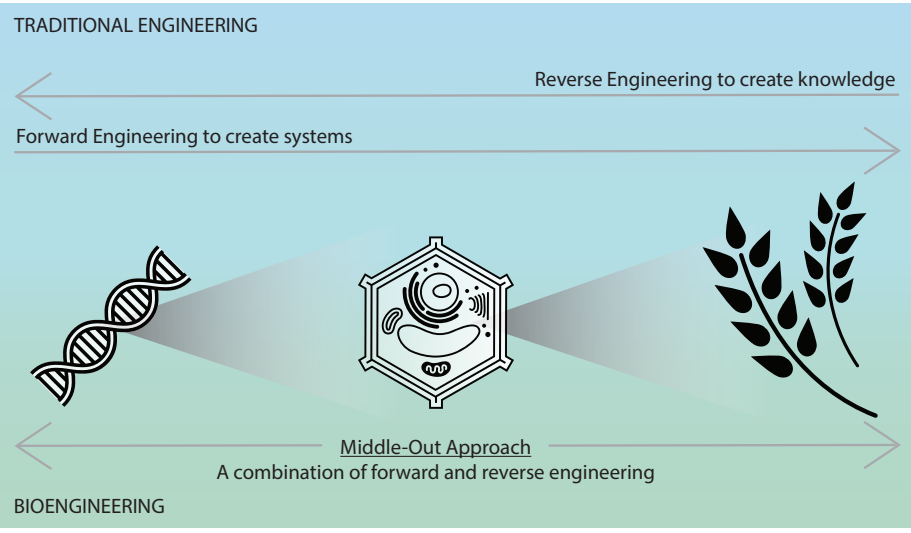
Engineering Biology
The engineering of biology has been at the heart of iGEM from the beginning: iGEM is an acronym for "international genetically *engineered* machine". However, there has been little discussion of the engineering process or what it takes to engineer biology. Here, we seek to outline the engineering method and bring it to the attention 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 “What to look for and reward in an iGEM project” on page 14.

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 subcomponents, 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?

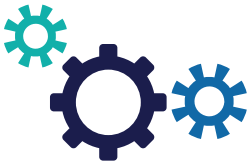


References

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

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 system 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.



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 in 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 their 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 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 **parts collections**, how well characterized are they? Is this clearly documented on the Registry? Would you be happy to see your next iGEM team 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 Human Practices

Human Practices (HP) is the "bigger picture" part of iGEM. The **Human Practices Hub** (https://2021.igem.org/Human_Practices) contains a wealth of information, resources and examples, including **Frequently Asked Questions** (https://2021.igem.org/Human_Practices/Introduction#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.
- **Responsible,** communicating honestly and considering how their project could impact the world, for better or worse.
- **Responsive,** listening to and learning from stakeholders and others they engage with, and aiming to "close the loop" between their design and the world.

In general, we want to see the teams draw on their Human Practices work to construct evidence-based arguments in support of their technical 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 theatre. They have consulted and shared their experiences with stakeholders, constituents and policymakers in their countries, as well as with international forums such as the United Nations. Although often an appropriate method, teams **do not need to directly engage with stakeholders** to successfully investigate Human Practices issues.

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 track 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 should demonstrate that went beyond just considering "bigger picture" issues, and responded 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** prize recognizes exceptional work based on the gold medal requirements for Human Practices. Teams should demonstrate how their investigation of HP issues has been integrated into the purpose, design and/or execution of their project in a particularly meaningful and creative way. See more details in the special prizes section starting on page 45.

Important Notes on Activities Involving Humans

- **Teams must comply with iGEM's Safety Policies, including the human experimentation (https://2021.igem.org/Safety/Policies#human) and human subjects (https://2021.igem.org/Safety/Policies#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 the HP Hub and HP Committee members) to **ensure their survey designs are valid and legitimate.**

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.
- 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 described differently on their respective wiki pages.

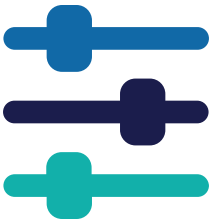
On Measurement

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 products 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.

What Happens When I Cast a Vote?

Judges are often curious as to how their votes affect the final outcome of the Giant 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!

Each judge casts votes in the judging ballot for a team 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:

Medals
Median medal vote
(rounded up if median is between medals)

Finalists
Highest score from a weighted average of the Project, Presentation, and Wiki categories

Track Prizes
Highest score from a weighted average of the Project, Presentation, and Wiki categories within a track

If there is a sufficiently high number of teams in a track, prizes will be given to the highest-scoring team within each division (i.e., Undergraduate and Overgraduate)

Special Prizes
Highest average score from the relevant rubric category

Note that all final 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. As you can see, 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) links. We refer to these pages 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 prizel on these standard pages. For example, if a team wishes to compete for the Best Plant Synthetic Biology special prize, they need to complete the **Plant Page** on: https://2021.igem.org/Team:Example2/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 and have supplementary material on separate pages, as you would with supplementary data in a publication.

What does this mean?

Regardless of how teams style their wikis, they will need to preserve designated URLs in order to be evaluated for the awards listed starting on page 45. Web design packages that create their own dynamic links will not work with our evaluation system. Judges should also look for content hosted on external sites as teams who do this are ineligible for the wiki award and may be ineligible for any medal.

So 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 37 and for special prizes on page 45. All content (except part pages on the Registry) should be contained in the official team name space.

For example: https://2021.igem.org/Team:Example2.

CHAPTER 2

Excellence in iGEM

Finalist Case Studies

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 video presentation and attendance at the Jamboree, and, depending on the track, a deliverable to be used by 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 much did the team accomplish (addressed a real world problem, produced BioBricks, carried out Human Practices, created a wiki, presentation, etc.)?**
2. **How impressive is this project?**
3. **Did the project work or is it likely to work?**
4. **Is the project likely to have an impact?**
5. **How well were engineering principles used (e.g., design-build-test cycle, use of standards, modularity, etc.)?**
6. **How thoughtful and thorough was the team's consideration of Human Practices?**
7. **How much of the work did the team do themselves and how much was done by others?**
8. **Did the team design a project based on synthetic biology and standard components (BioBricks, software, etc.)?**
9. **Are the project components well documented on the team's wiki/Registry pages (parts should be documented in the Registry)?**
10. **How competent were the team members at answering questions?**

Regardless of project or track type, excellent teams do not necessarily need to score highly in every aspect; they 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 how much teams achieved in a given time, which is not limited to "tick box" criteria that they check off as they complete.

To get a better idea of what judges recognize as exemplary, we will explore four finalists' projects:

- **GreatBay SZ 2019:** https://2019.igem.org/Team:GreatBay_SZ
- **Vilnius-Lithuania 2017:** http://2017.igem.org/Team:Vilnius-Lithuania
- **Imperial College 2016:** http://2016.igem.org/Team:Imperial_College
- **UC Davis 2014:** http://2014.igem.org/Team:UC_Davis

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.

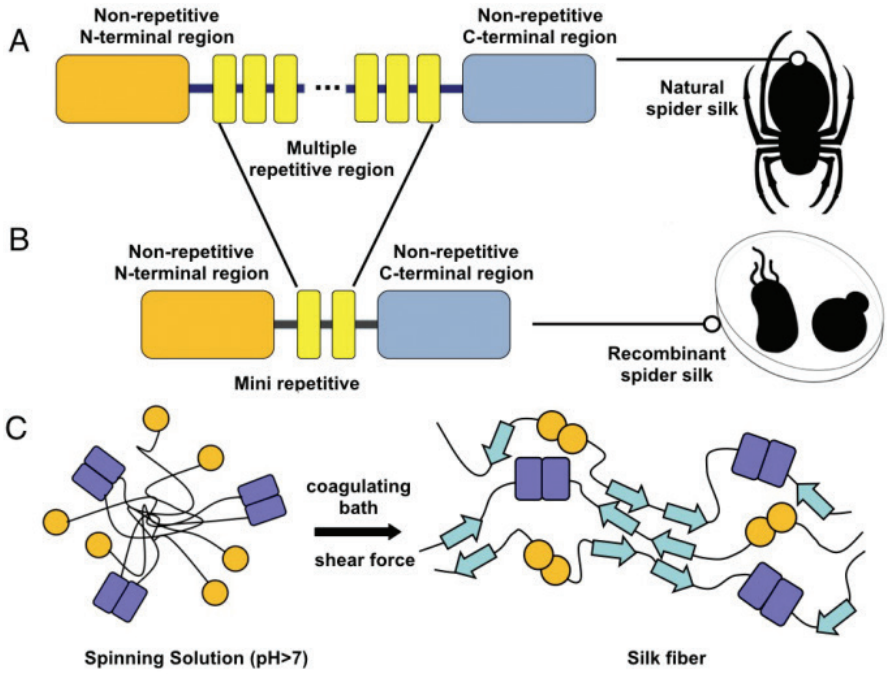


Figure. 1 Compare between natural spidroin structure and mini-spidroin structure. A.The structure of natural spidroin. B.The structure of mini-spidroin. C.The protein conformation due to alternating pH that forms silk.

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 pH. 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.

Finally, 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 under visible light (panels A, B, C in their Figure 15 below) and fluorescent light (panels D, E, F).

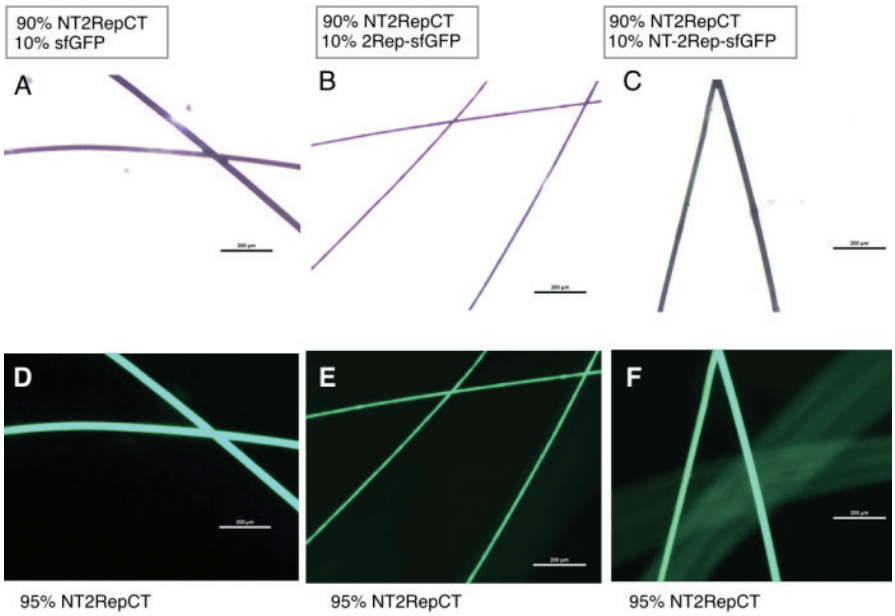


Figure. 15 Electron microscopy images of fibers formed from 90%NT2RepCT spidroin mixing with respectively 10%sfGFP, 10%2Rep-sfGFP, and 10%NT-2Rep-sfGFP. The fibers from sfGFP:NT2RepCT 1:9 (25.5um) (A), The fibers from 2Rep-sfGFP:NT2RepCT 1:9 (9.6um) (B), The fibers from NT-2Rep-sfGFP:NT2RepCT 1:9 (21um) (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 also 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

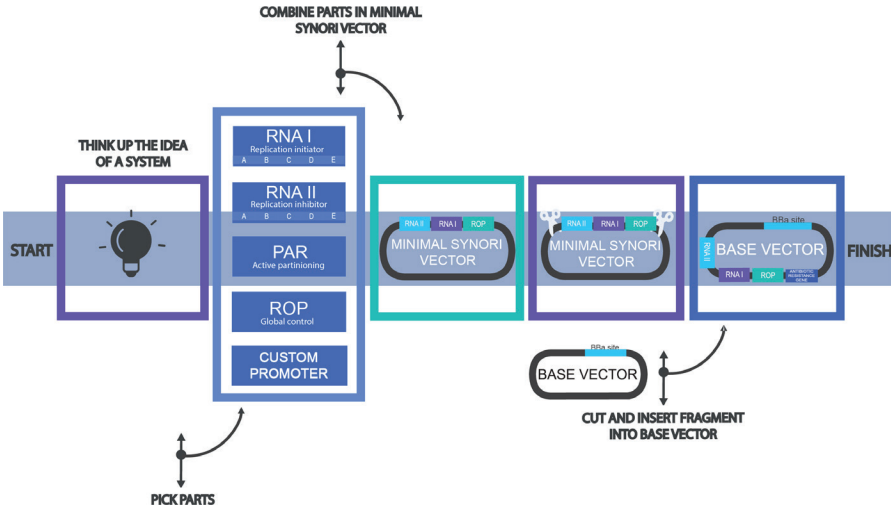
SynORI – a framework for multi-plasmid systems

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 for up to five different plasmids per cell and an active partitioning system to ensure plasmid stability during cell division.

The resulting system should be easy adaptable for different scientific problems:



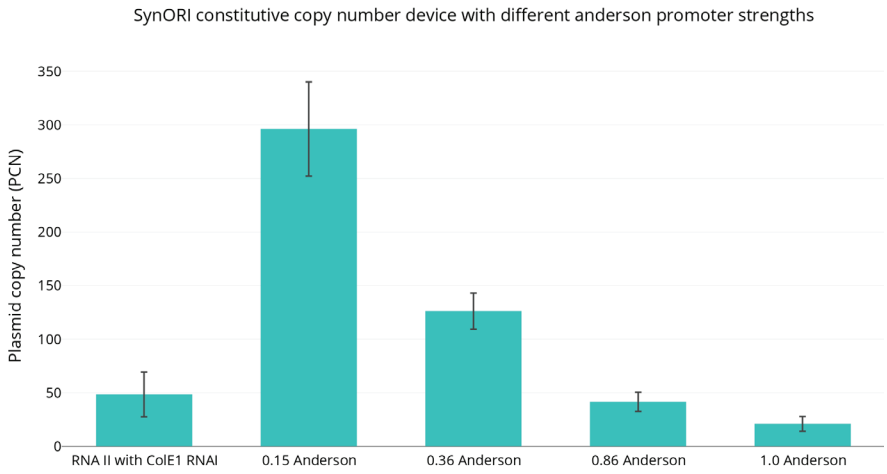
The team's vision is a standardized, easy adaptable system to be used for multi-plasmid system of different purposes.

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.

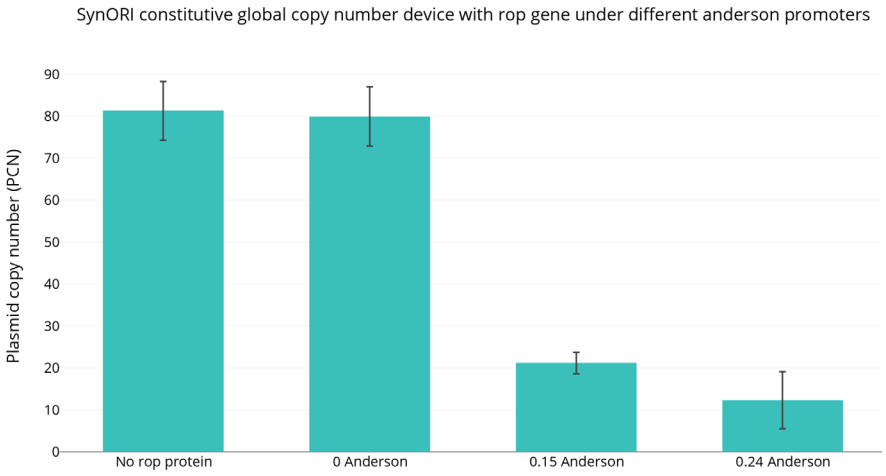
Next, the ColE1 ORI was re-engineered in order to gain control over the PCN. ColE1 consists of two antisense RNA molecules: RNA I and RNA II. RNA I is known to inhibit replication as RNA II is seen as the activator of replication. Vilnius-Lithuania marked the RNA I gene and its promoter as their primary 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.



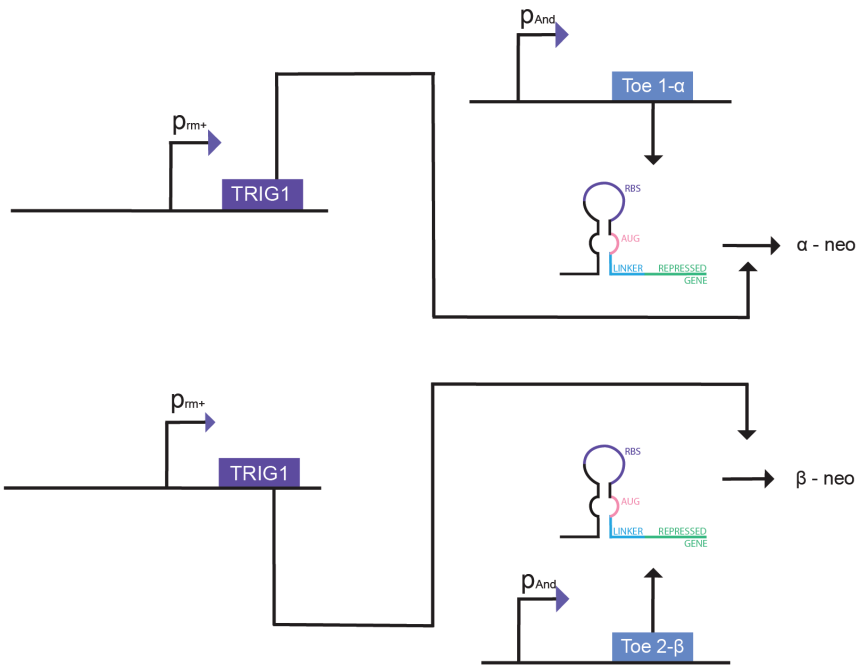
Constitutive control over the PCN by "exchanging" the native RNA I promoter with Anderson promoters of different strength.

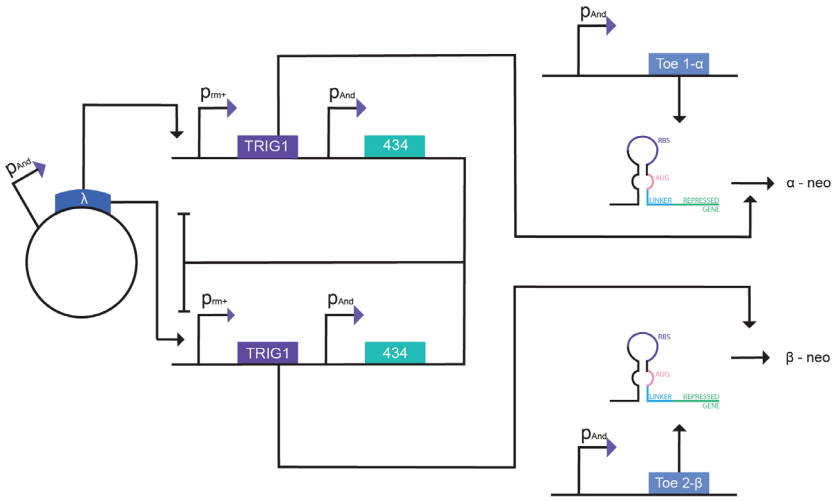
After being able to control the PCN of a plasmid, the team established control over multi-plasmid groups and subsequently global control over all plasmid groups simultaneously. By testing different secondary structures of the RNA I and RNA II in search of the perfect interplay between RNA I and II, the 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.

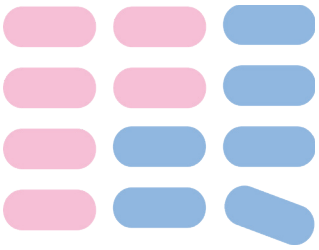
Finally, the team needed a selection system to maintain high numbers of different plasmids in their system. Their approach was based on a split antibiotic resistance gene. The two parts of the gene were divided on two plasmids. If both plasmids were maintained in the cell, then the antibiotic resistance 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.





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.

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. 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.



Imperial College London

Imperial College London 2016

http://2016.igem.org/Team:Imperial_College

Imperial College London was the undergraduate Grand Prize winner of the Giant Jamboree in 2016. The Imperial College London 2016 iGEM team decided to tackle the problem of growing co-cultures in the lab, as different microorganisms exist together in their natural ecosystems.

However, this strategy is difficult to do in vitro because each culture requires a different set of growth conditions. Applications of using co-cultures are endless and range from using antibiotic-free human therapeutics to preventing pathogenic bacteria from growing on spacecraft.

To that end, they designed a genetic circuit that allows ratiometric control of populations in co-culture.

The genetic circuit had three components:

1. A communication module that utilises quorum sensing to allow the *E. coli* bacteria population and the other bacteria co-population to detect their own population density

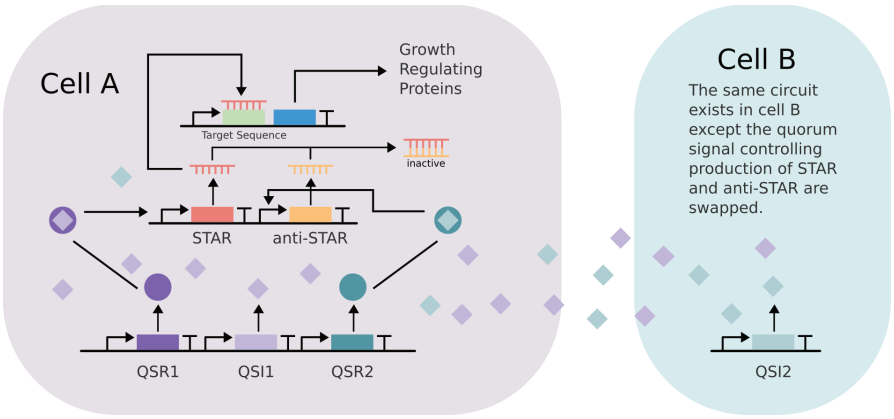
2. The comparator module that links quorum sensing to RNA logic so that the population can compare their own population to the other population cell-line

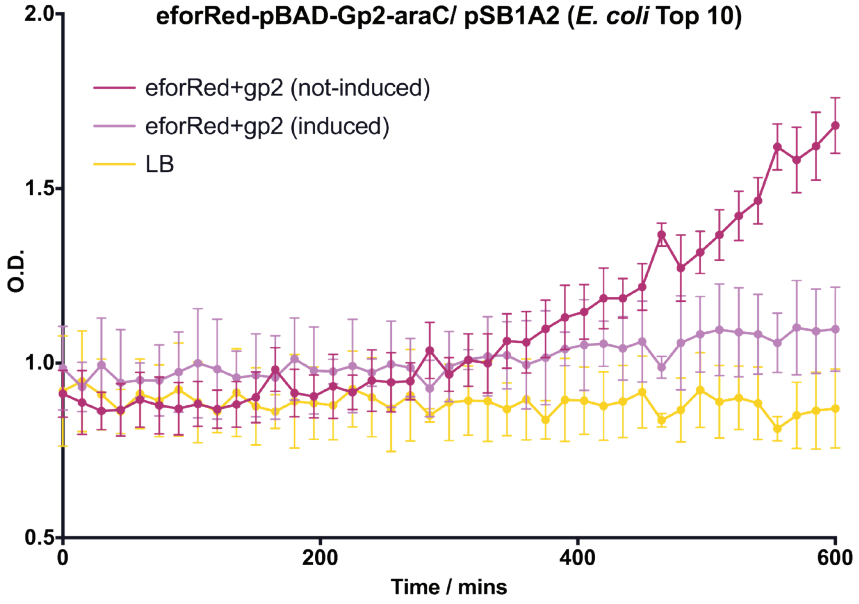
3. A growth regulation module that allows the cell line to respond to the signal from the comparator's module to regulate each other's population growths

These three components make up the Genetically Engineered Artificial Ratio (GEAR) system as shown in the figure on the next page.

As proof of principle they transformed two cell populations with different chromoproteins. They showed that co-cultures fail because one culture will grow faster than another. In order to show that control of growth could be used to produce a stable co-culture that could maintain its ratio over time, they combined the arabinose-inducible Gp2 construct (growth regulating protein expressed from a phage gene that was used for their G.E.A.R. system) with a construct for the chromoprotein, eforRed.

When arabinose was added, the growth of Gp2 was inhibited. As you can see from the graph on page 32 the efoRed+Gp2 construct showed a decrease in growth rate when induced with arabinose, suggesting that their genetic circuit was a suitable system for controlling the growth of cells in co-culture.

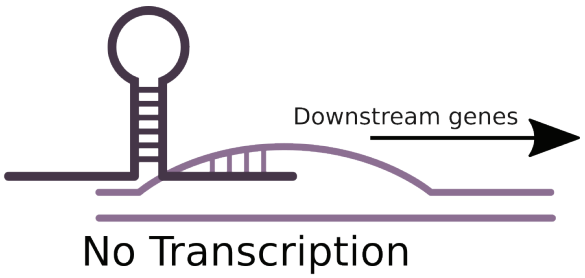




This project was impressive especially in their design using engineering principles of the co-culture experiments, the amount of work done in characterizing their components and also incorporating mathematical modeling of each module of the GEAR system. They have shown that they were able to accomplish many of their set tasks.

There are many aspects that were creative in this project. For example, they were the first iGEM team to introduce a small transcriptional-activating RNA (STAR) that was used for transcriptional regulation in their comparator module. It works by binding to an introduced terminator just upstream of the growth-inhibiting gene interfering with the hairpin structure, thus allowing transcription to be turned on. One of the key advantages of using STAR is it has very tight regulation.

This part won the **Best New Basic Part** (http://2016.igem.org/Team:Imperial_College/Basic_Part)



No Transcription

Transcription

In addition to this standard part, they submitted an impressive number of composite parts to the iGEM (http://2016.igem.org/Team:Imperial_College/Composite_Part) Registry that have been well characterized and documented.

They were the first iGEM team to use a tool to integrate social policy and lab research called Socio-Technical Integration Research protocol **STIR** (http://2016.igem.org/Team:Imperial_College/Integrated_Practices). This tool can be used by future iGEM teams to provide an initial framework for their projects.

They also designed a computer software tool called **Advanced Logging Interface for Culture Experiments (ALICE)** http://2016.igem.org/Team:Imperial_College/Software which will be helpful to other iGEM teams when they design their own co-culture experiments.

These parts and tools are readily accessible to the iGEM community and are likely to have an impact on other teams.

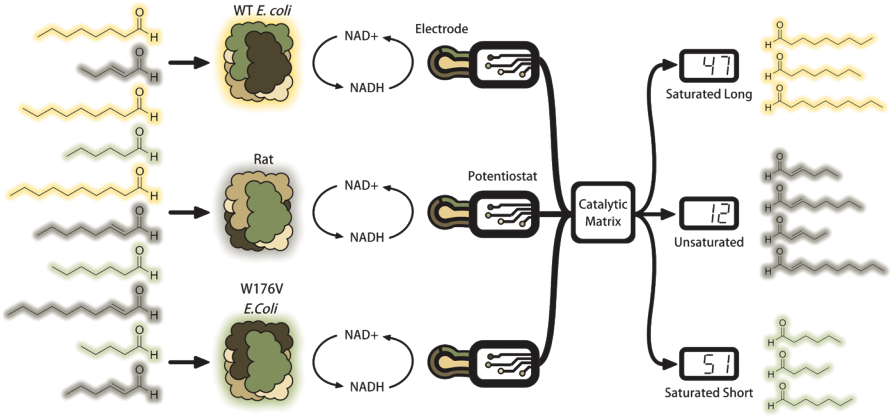
The judges were very impressed by the Human Practices where the team designed a game that explains co-cultures to the general public that is fun and is clearly understood by anyone and is available as an **App** (http://2016.igem.org/Team:Imperial_College/Engagement#Game) The team clearly stated in their wiki the attributions and their collaborations.

Apart from the impressive data from the wet and dry lab experiments, the team produced a wiki and poster that were both fun and eye-catching with high quality graphics, resulting in their also winning the Best Wiki and Best Poster special prizes.

UC Davis 2014

http://2014.igem.org/Team:UC_Davis

UC Davis was the 2014 overgraduate section champion. After learning that over 70% of imported olive oils and many US olive oils are rancid, UC Davis chose to develop a method to help ensure consumers receive quality extra virgin olive oil. Their "OliView" project consisted of these major components: 1) protein engineering; 2) electrochemistry; 3) potentiostat development; and 4) signal processing. The development of an enzyme-based electrochemical biosensor for the evaluation of rancidity in olive oil is nicely summarized in the "How Did We Do It?" diagram:



Let's look at specific aspects addressed by their project.

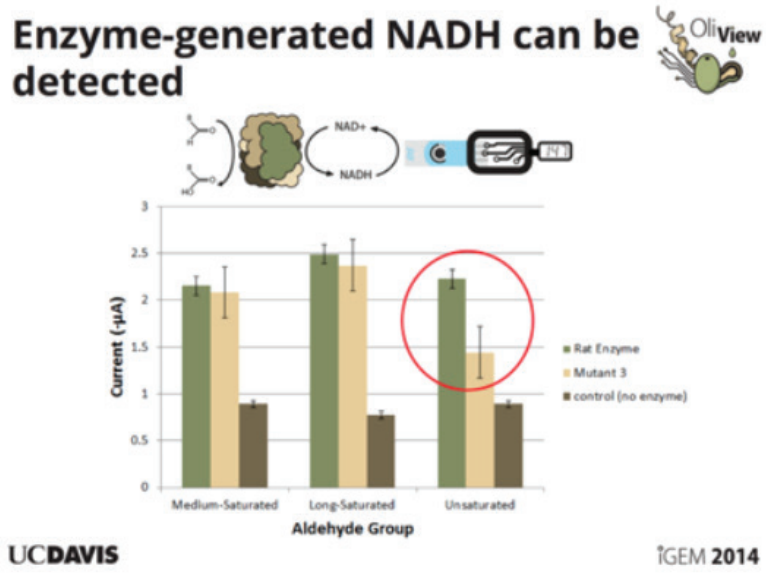
First, they identified NAD+ dependent aldehyde dehydrogenases with unique specificity profiles from online databases and designed 20 mutants of *E. coli* aldehyde dehydrogenase. They developed a simple spectrophotometric plate assay which measured the concentration of NADH in a solution. Using this assay, they screened 23 aldehyde dehydrogenases against all sixteen aldehyde substrates they previously identified to occur in olive oil. They identified three enzymes with unique specificity profiles:

Average Catalytic Efficiency for Each Enzyme on Each Bin

	Medium, saturated Aldehydes (C5-C7)	Long, saturated Aldehydes (C8-C10)	Unsaturated Aldehydes
WT *E. coli* ALDH	100%	95.30%	8.40%
W176Q Mutant *E. coli* ALDH	98.73%	100%	1.82%
WT Rat ALDH	100%	75.48%	71.01%

They needed to develop an electrode system to detect enzyme activity via NADH. To accomplish this part of their project, they acquired, selected, and optimized an electrode setup for the detection of NADH at low concentrations in a complex solution. Additionally, they built and tested a potentiostat to measure enzyme-generated NADH.

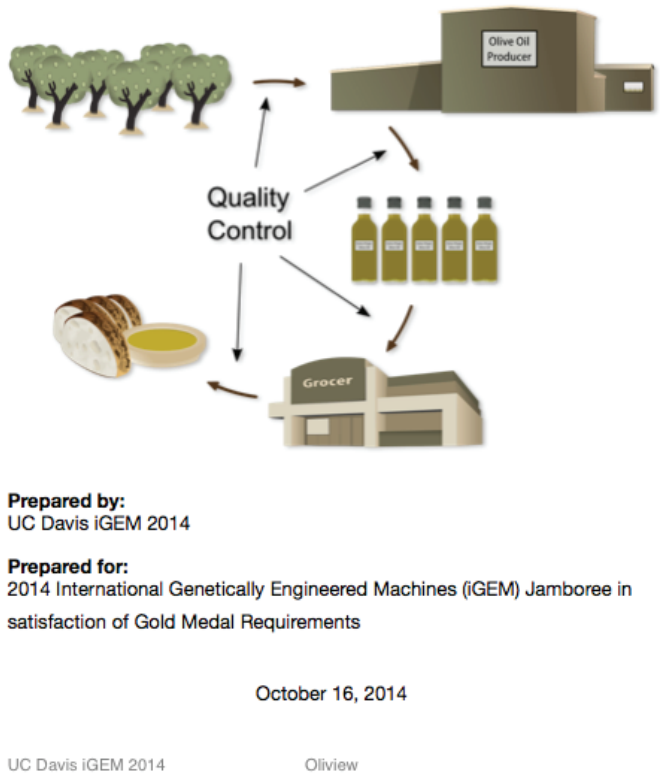
After validating that their system could detect enzyme activity, they developed a mathematics and software suite to connect measured aldehyde profiles to the degree of rancidity in a particular olive oil. They tested their working model with nine samples of extra virgin olive oil. They successfully detected two out of three rancid samples (as determined by a more traditional, more expensive method).



To satisfy the gold medal requirement for Human Practices, UC Davis conducted an in-depth analysis of how customers and stakeholders in the olive oil industry influenced their project and how their project could possibly impact them.

Throughout the summer, the team met with representatives from the largest producers of extra virgin olive oil in California. They toured production facilities and learned about industrial quality control. Inspired by discussions about producer interest in new analytical devices, they chose to build a new device to detect aldehydes in rancid olive oil.

After participating in several olive oil tastings, they decided to reach out to the community by holding their own olive oil tasting to educate consumers about how rancid olive oil tastes as compared to fresh olive oil. In addition, they attended a public hearing organized by the California Department of Food and Agriculture at the State Capitol to record evidence and testimony presented by olive growers, millers, and the general public on a set of standards proposed by the Olive Oil Commission California (OOCC). Human Practices was deeply integrated with the team's project and substantially addressed broader concerns.



UC Davis won Best Policy & Practices Advance, Overgrad section.

UC Davis was the Grand Prize Winner of the Overgrad section at the iGEM 2014 Giant Jamboree. The judges were impressed with how the project was designed and executed. The motivation for and potential applications of the project were clearly defined. Engineering principles were professionally incorporated into the project. Additionally, the project was clearly communicated to a wide audience on the team wiki and poster and in the presentation.

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.

Medals allow us to celebrate the accomplishments of our iGEM teams. Through medals, we highlight the underlying principles of iGEM: respect, community, and honesty.

The three levels of medals, from lowest to highest are Bronze, Silver, and Gold, with each medal building upon the next. Through the bronze we appreciate the hard work and effort teams have put into participating in iGEM, the silver celebrates their accomplishments, and with the gold we delight in their excellence.

We do not limit the numbers of each medal and all teams can earn a medal; teams are only competing with themselves to achieve the medal criteria.

For a bronze medal, teams must meet all 4 bronze medal criteria. For a silver medal, teams must meet the 4 silver medal criteria in addition to the 4 bronze medal criteria. For a gold medal, teams must meet at least 3 of the 7 available gold medal criteria in addition to all of the bronze and silver medal criteria.

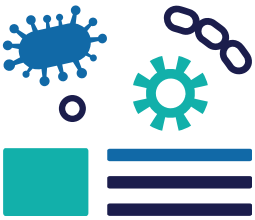
Changes in Medals due to the Pandemic

Last year, the major changes we implemented in medals allowed teams to achieve a Bronze, Silver, or Gold medal without doing laboratory work. We have kept those changes in place this year. Many of the changes we’ve made to the criteria have opened up the ways in which teams can achieve that criteria. With more open criteria, we wanted to provide teams with some guidance, ideas, and suggestions for how to think about and approach each criteria, and to give teams fewer restrictions so that they can surprise us with their work. **You may find that teams have fulfilled a criteria by doing work in ways that you didn’t expect.**

As you judge teams this year, please keep this in mind, and also reflect on how we want to celebrate the work of the teams.

What if the team can access their laboratory?

If a team has access to a laboratory this year, they can still use laboratory work for medal criteria. In particular, they can: contribute new data to an existing Part (Bronze #4), design and build a new Part and show that it works as expected (Silver #1), or make a new Part that improves the function of an existing Part (Gold #2). Lab work may also be used in modeling work (Gold #3) and to help show that their whole system works (Gold #4).



What about Parts?

If a team is working with parts for the Bronze #4, Silver #1, Gold #2 medal criteria, or Part Special Prizes, **those parts must be added to the Registry and documented on the relevant part's pages**.

Teams can create new parts this year without laboratory access, so some teams may lack experimental data on their pages. Teams may have background information, design documentation, modeling data, and/or experimental characterization for parts. Depending on the criteria, these may be considered as useful information for parts and should be evaluated appropriately.

- Bronze #4: examples of a contribution for an Existing Part could be: new background information, detailed part design documentation, new modeling data, and/or new experimental characterization
- Silver #1: examples of engineering success for a New Part could be: detailed part design documentation, modeling data, experimental characterization and/or detailed, rigorous experimental design
- Gold #2: improvement of an Existing Part must show new experimental characterization for a New Part. **This is the only medal criteria that requires lab work.**

Medals Guidance

Many of the changes we've made to the criteria have opened up the way in which teams can achieve that criteria. With more open criteria, we wanted to provide teams with some guidance, ideas, and suggestions for how to think about and approach each criteria. You can see this guidance in the Medal Criteria table on the following pages.

Celebrating Their Work

A Bronze medal is awarded to those teams that have participated in iGEM 2021, presented their work, and made a contribution for future teams.

A Silver medal is awarded to those teams that have addressed these key pillars of an iGEM project: engineering success, collaboration, and human practices.

A Gold medal is awarded to those teams that have shown excellence in multiple areas beyond the Silver medal.

Bronze

All criteria must be met

All Tracks	Guidance Provided to Teams
1. Competition Deliverables Complete the following Competition Deliverables: Wiki Presentation Video Judging Form	*For guidelines for each of the deliverables, please see the links below:* **Wiki** https://2021.igem.org/Competition/Deliverables/Wiki **Presentation Video** https://2021.igem.org/Competition/Deliverables/Presentation **Judging Form** https://2021.igem.org/Competition/Deliverables/Judging_Form You can also directly navigate to these links from the **Competition Deliverables page**: https://2021.igem.org/Competition/Deliverables
2. Attributions Describe what work your team members did and what other people did for your project.	*For guidelines for this deliverable, please see the link below:* **Attributions** https://2021.igem.org/Competition/Deliverables/Project_Attributions *Some questions to help guide you:* • What did each team member work on during your project? • Did you get help from outside sources, such as technicians or other faculty members? *Note:* This is not about literature citations (put these throughout your wiki!)
3. Project Description Describe how and why you chose your iGEM project.	*For guidelines for this deliverable, please see the link below:* **Project Description** https://2021.igem.org/Competition/Deliverables/Project_Description *Some questions to help guide you:* • Why do you believe your project is a useful application of synthetic biology? • What are your project goals and how will you achieve them? • What work outside or inside of iGEM inspired your project? *Note:* You can also describe how COVID-19 impacted your project

4. Contribution
 	
Make a useful contribution for future iGEM teams.
	Some ways to achieve this include:
	
	• 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
	
	We invite you to also think outside of these areas for your contribution.

Silver

All Bronze criteria must be met, plus all Silver criteria below must be met

All Tracks	Guidance Provided to Teams
1. Engineering Success Demonstrate engineering success in a part of your project by going through at least one iteration of the engineering design cycle.This achievement should be distinct from your Contribution for Bronze.	*Engineering success can be achieved by making an effort to follow the engineering design cycle:* Design → Build → Test → Learn → Design... • We invite you to think about ways to tackle and solve one or more of your project's problems and use synthetic biology tools to generate expected results. • If you are unable to get into a lab, how would you design your experiments, evaluate the outcome, deal with unexpected results, and plan further steps? • See the **Engineering Hub** (https://2021.igem.org/Engineering) for additional guidance on engineering success. *Note:* For teams who can get into lab, you can design and build a new Part and show that it works as expected (documentation must be on the Part's Pages on the **Registry** (http://parts.igem.org/Main_Page)
2. Collaboration Collaborate with one (or more) 2021 iGEM team(s) in a meaningful way.	*Some ways to achieve this include:* • Mentor a team (or be mentored by a team) • Troubleshoot a project • Host a (virtual) meetup • Model/simulate a system • Validate a software/hardware solution to a synthetic biology problem We invite you to also think outside of these areas for your collaboration. *Notes:* • This can be a one-way collaboration where one team benefits from another team • Simply filling out a survey for a team is not enough to demonstrate a significant interaction.
3. Human Practices Explain how you have determined 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 are appropriate values in the context of your project? • What evidence do you have to show that your project is responsible and good for the world? *Note:* You should draw on personal reflections, background research, and/or engagement with communities relevant to your project. Please visit the **Human Practices Hub** (https://2021.igem.org/Human_Practices) for more information on how to carry out Human Practices work.
4. Proposed Implementation Explain how you would implement your project in the real world.	*Some questions to help guide you:* • Who are your proposed end users? • How do you envision others using your project? • How would you implement your project in the real world? • What are the safety aspects you would need to consider? • What other challenges would you need to consider? *Notes:* • Teams already think about some of these issues for the Safety Form • This will encompass engineering, safety, and implementation

Gold

All Bronze and Silver criteria must be met, plus at least three (3) Gold criteria below must be met

All Tracks	Guidance Provided to Teams
1. Integrated Human Practices Demonstrate how your team responded to your Human Practices reflections, research, and/or engagement. You should show how your activities impacted your project purpose, design and/or execution.	*Some questions to help guide you:* • How did your Human Practices work inform and shape your project at different stages? • How did your team choose to respond to your Silver medal work? How did your Silver medal Human Practices and Proposed Implementation inform your ethical, technical, safety and/or communication decisions? • How did you decide which needs or values to prioritize in your project's design? What compromises, if any, did you choose to make and why? • How did your team "close the loop" between what was designed and what was desired? Please visit the **Human Practices Hub**: (https://2021.igem.org/Human_Practices) for more information on how to carry out Human Practices work.
2. Improvement of an Existing Part Make a new Part that improves the function of an existing Part. This improvement must be distinct from your work for Bronze and Silver medals. Team to enter the Existing Part Number and the New Part Number in their Judging Form.	*Some things to consider when designing and showing your improvement:* • Your experiments should be done with both the improved part and the original part as a control • The sequences of the new and existing parts must be different • Adapting the part to a different assembly standard does not count as a functional improvement • See the **Engineering Hub** (https://2021.igem.org/Engineering) for details on how to measure your parts • You must document the improvement on the Registry on both the existing and new part pages. See the **Registry Document Parts page** (http://parts.igem.org/Help:Document_Parts) for instructions *Note:* This criteria was kept in as an option for teams who could get into the lab.
3. Project Modeling Use modeling to gain insight into how your project works or should be implemented. Explain your model's assumptions, data, parameters, and results in a way that anyone could understand.	*Some ways to achieve this include:* • Deterministic, exploratory, molecular dynamic, and/or stochastic models • Explore the physical modeling of a single component within a system • Utilize mathematical modeling for predicting function of a more complex device *Note:* This could be either a new model you develop or the implementation of a model from a previous team. Please see the **Software Tools** (https://2021.igem.org/Resources/Software_Tools) page for resources that may help with your modeling.

Continued in next page.

Gold

All Bronze and Silver criteria must be met, plus at least three (3) Gold criteria below must be met

All Tracks	Guidance Provided to Teams
4. Proof of Concept Expand upon your Silver medal work for Proposed Implementation and develop a proof of concept for your project.	*A proof of concept usually consists of experiments or prototypes that demonstrate that your project is likely to work in a relevant context.* • Your Proof of Concept should reflect your project as a whole, not just a single aspect or component • Depending on your project, this criterion may require lab work. Software- or hardware-based projects may not require lab work for a successful proof of concept • All activities must follow **iGEM Safety Committee** (https://2021.igem.org/Safety) rules and policies
5. Partnership Collaborate throughout the year with at least one other 2021 iGEM team on a set of shared objectives related to both of your projects. This partnership should go beyond a Silver medal collaboration.	*Some questions to help guide you:* • How did your collaborative work inform and shape your project at different stages? • How did each team in the partnership benefit from the collaboration? • How did your teams work together throughout the season? *Note:* Compared to the Silver Medal Collaboration criterion, partnerships should be more central to the success of both teams' projects and teams should be working together throughout the season (not a single interaction). A Partnership and the Silver Medal Collaboration may be done with the same team(s).
6. Education & Communication Develop and implement education, science communication, and/or outreach materials related to synthetic biology. All activities must follow Safety policies for Human Subjects Research https://2021.igem.org/Safety/Policies#subjects.	*Some questions to help guide you:* • How did you determine the type of materials you produced? • Who is your target audience and how will your materials be used by that audience? • How will your materials encourage an open dialogue with your audience? • How did you make your materials accessible to a wider audience? *Note:* The work should be substantial and show excellence.
7. Excellence in Another Area Demonstrate excellence in another area related to synthetic biology.	*Surprise us! For this criterion, your work should be something that does not fulfill another medal criterion* • The work should be substantial • The work does not have to directly relate to your project (for example, art and design, entrepreneurship, diversity and inclusion, broad synthetic biology policy, etc.) • Your wiki documentation should demonstrate the connection to synthetic biology • All activities must follow **iGEM Safety Committee** (https://2021.igem.org/Safety) rules and policies

Standard Pages for Medals

Below are standard links to the team "Example2" 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.

Bronze

Bronze #1 (Deliverables):
No standard wiki page required.

Bronze #2 (Attributions):
https://2021.igem.org/Team:Example2/Attributions

Bronze #3 (Project Description):
https://2021.igem.org/Team:Example2/Description

Bronze #4 (Contribution):
https://2021.igem.org/Team:Example2/Contribution

If using a part to fulfill this criteria, documentation must be on the Part's Main Page on the Registry.

Silver

Silver #1 (Engineering Success):
https://2021.igem.org/Team:Example2/Engineering

If using a part to fulfill this criteria, documentation must be on the Part's Main Page on the Registry.

Silver #2 (Collaboration):
https://2021.igem.org/Team:Example2/Collaborations

Silver #3 (Human Practices):
https://2021.igem.org/Team:Example2/Human_Practices

Silver #4 (Proposed Implementation):
https://2021.igem.org/Team:Example2/Implementation

Gold

Gold #1 (Integrated Human Practices):
https://2021.igem.org/Team:Example2/Human_Practices

Gold #2 (Improvement of an Existing Part):
No standard wiki page required.
Data must be on the Part's Main Page on the Registry.

Gold #3 (Project Modeling):
https://2021.igem.org/Team:Example2/Model

Gold #4 (Proof of Concept):
https://2021.igem.org/Team:Example2/Proof_Of_Concept

Gold #5 (Partnership):
https://2021.igem.org/Team:Example2/Partnership

Gold #6 (Education & Communication):
https://2021.igem.org/Team:Example2/Communication

Gold #7 (Excellence in Another Area):
No standard wiki page required. Team to enter URL in their Judging Form. The URL must be from the Team's wiki pages.

CHAPTER 4

Special Prizes

Introduction

Special prizes are awarded to teams in iGEM who excel in specific areas of the competition. All Track teams are eligible for special prizes and they will be distributed by section (ex: Undergraduate, Overgraduate, and / or High School). Exceptions for special prizes: Software Track teams are not eligible for the software tool special prize and Hardware Track teams are not eligible for the hardware special prize.

Undergraduate, Overgraduate, and High School sections will each receive each type of prize, provided that:

1. More than 10 teams are competing for the prize
2. The work is scored high enough to warrant distributing the award by the judges
3. Enough judges vote for the special prize in question

All information regarding special prize eligibility should be found on the appropriate standard wiki page as described on page 47. If the information is not found there, then a team will be considered ineligible for that prize.

The iGEM 2021 Judging Program Committee hopes to award the following special prizes, conditional on the accomplishments presented by the teams:

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

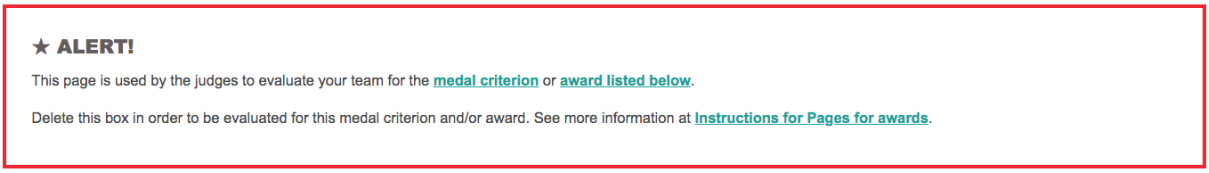
For most special prizes, teams must also provide a 150 word description of what they accomplished on their Judging Form in order to be evaluated for that prize. Exceptions to this requirement are the Best Wiki and Best Presentation special prizes. These two special prizes do not require teams to provide a 150 word description to be eligible for the award.

Standard Pages for Special Prizes

Teams need to edit the following standard pages to compete for the specified award.

Education	https://2021.igem.org/Team:Example2/Education
Hardware	https://2021.igem.org/Team:Example2/Hardware
Inclusivity Award	https://2021.igem.org/Team:Example2/Inclusivity
Integrated Human Practices	https://2021.igem.org/Team:Example2/Human_Practices
Measurement	https://2021.igem.org/Team:Example2/Measurement
Model	https://2021.igem.org/Team:Example2/Model
Plant Synthetic Biology	https://2021.igem.org/Team:Example2/Plant
Software Tool	https://2021.igem.org/Team:Example2/Software
Supporting Entrepreneurship	https://2021.igem.org/Team:Example2/Entrepreneurship
Sustainable Development Impact	https://2021.igem.org/Team:Example2/Sustainable

The following wiki code appears on all evaluated pages. Teams need to remove it to let the system know they are competing for an award.



Special Prizes and Awards with no required standard page

- Best Basic Part
- Best Composite Part
- Best Part Collection
- Best Wiki
- Best Presentation
- Track Awards (based on total body of work, not any specific page)

Integrated Human Practices

Summary

- Recognizes exceptional work based on the gold medal Integrated Human Practices criteria (see “On Human Practices” on page 15 for helpful tips on evaluating Human Practices).
- Teams should show how they have carefully considered whether their project is responsible and good for the world **at many stages throughout** their project and that they have **reflected and acted** upon these considerations
- Teams should document a thoughtful approach to exploring these questions. Their Human Practices activities should address both ***why*** their project idea is important and ***how*** the idea should be implemented in practice.
- Teams should show that they have created feedback loops between their project work and the world in which it exists, and **demonstrate that the purpose, design and/or execution of their project evolved** based on the information acquired through their Human Practices activities.

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

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

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** (http://igem.org/Values), 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/process 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 and foresight, going beyond obvious issues to investigate whether their project is responsible and good.

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

UNSW Australia 2020

https://2020.igem.org/Team:UNSW_Australia/Human_Practices

The **UNSW Australia 2020** (https://2020.igem.org/Team:UNSW_Australia) team wanted to address widespread coral bleaching in the nearby Great Barrier Reef. They began their project by consulting with conservation experts, then spoke to social scientists and ethicists, building an understanding of the social landscape surrounding their project. This expert engagement helped them to ask stakeholders nuanced questions about what a "good" synthetic biology solution would look like. The team identified a diverse range of stakeholders to consult, including traditional indigenous owners of the land, bioprospecting researchers, local coastal community councils, and the tourism industry. Throughout these consultations, the team carefully documented how they integrated Human Practices into many design decisions, why they deliberately prioritised certain values, and how they "closed the loop" to align their project with stakeholder needs.

Calgary 2019

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

The **Calgary 2019** (https://2019.igem.org/Team:Calgary) 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** (https://2019.igem.org/Team:Sao_Carlos-Brazil) 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”, and 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.

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:

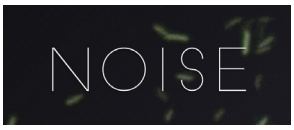
1. **How well did their work promote mutual learning and/or a dialogue?**
2. **Is it documented in a way that others can build upon?**
3. **Was it thoughtfully implemented?**
4. **Did the team convince you that their activities would enable more people to shape, contribute to, and/or participate in synthetic 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** (https://2020.igem.org/Team:UCopenhagen) 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. The team also discussed their plans to develop a biosensor 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

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** (http://2015.igem.org/Team:William_and_Mary/Practices) 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 have 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** (http://2018.igem.org/Team:Montpellier/Public_Engagement#Art) 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** (http://2018.igem.org/Team:Montpellier/Public_Engagement#Art) which directly responded to issues and questions raised in their engagement with non-scientists.

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 modelled 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:

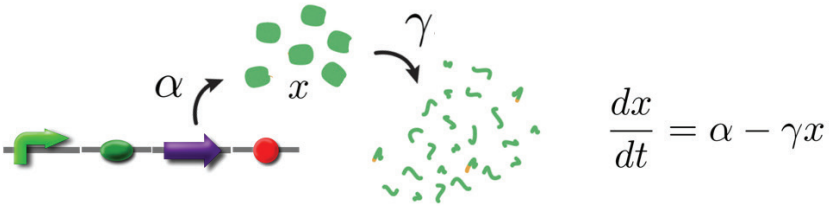
1. **How impressive is the modeling?**
2. **Did the model help the team understand a part, device, or system?**
3. **Did the team use measurements of a part, device, or system to develop the model?**
4. **Does the modeling approach provide a good example for others?**

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

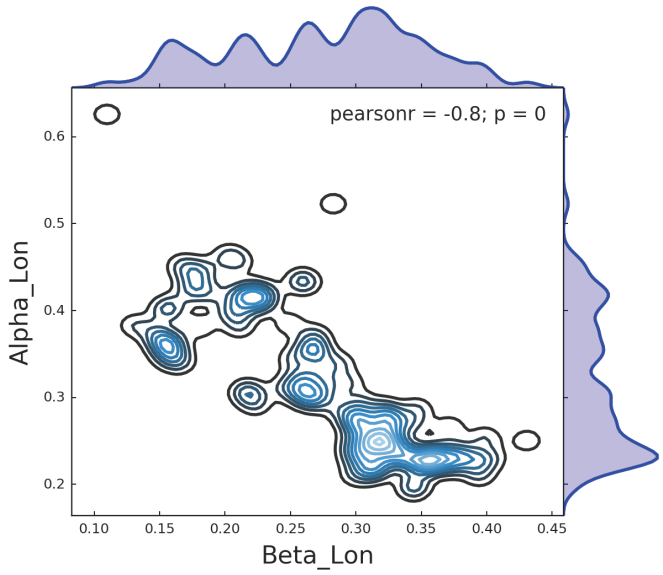
William and Mary 2017

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

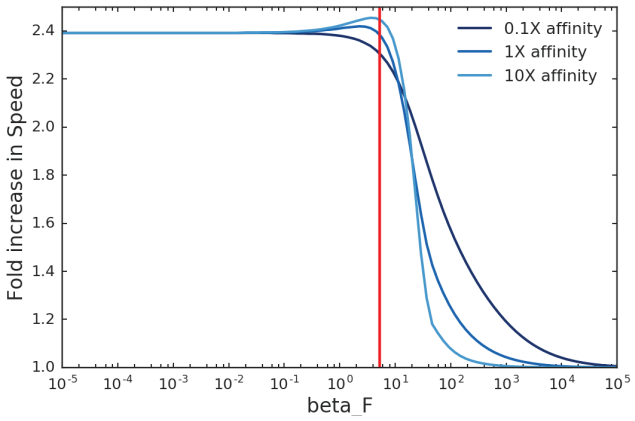
William and Mary were the 1st runner-up in the Undergraduate section in 2017, largely due to their impressive integration of experimental and modeling work. Their project focused on creating systems for tunable and dynamic protein expression via the design of protein degradation tags:



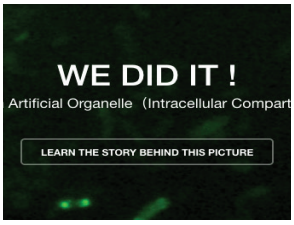
For their modeling, they first put together an ordinary differential equation (ODE) model, a common technique used by many teams. However, since little had been previously done to describe this type of system, this model was relatively novel. Furthermore, accurate parameters estimates for the ODE model were not necessarily available in the literature. Thus, to predict the values of their model parameters, the team performed a rigorous Bayesian Parameter Estimation with Markov Chain Monte Carlo. This method integrated experimental data they had generated. They performed and documented several iterations of their model, showing their progression towards increased reliability and accuracy. In terms of the rubric, the methods and process are impressive due to their novelty and relative challenge. Next, the model definitively helped the team understand their system, not only using their specific parts, but also to predict how it might behave in other contexts. For example, they found that the values of two parameters (Alpha_Lon and Beta_Lon) are tightly correlated and can only possess certain values in order to work together:



Next, using their model estimates, they used their model to predict their experimental system's behavior. For example, they found that using different protein degradation tags (pdts) did not affect the location of system saturation, but instead affects the rate at which saturation is achieved (i.e., whether the transition is sharp or gradual):



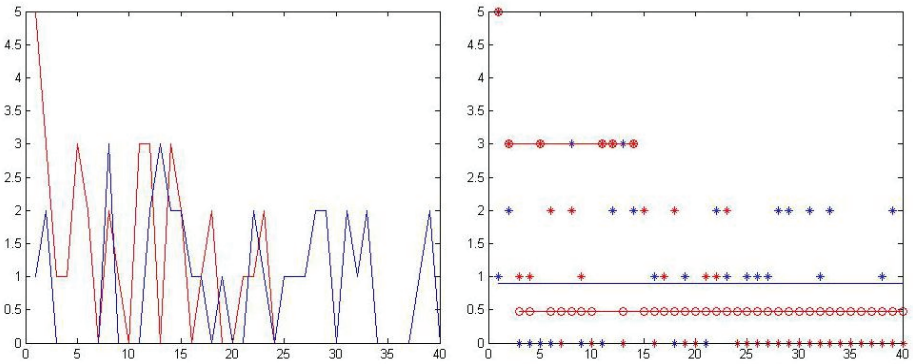
William and Mary further used their model to make several other useful predictions about the behavior of their system and what parameters would be most important to other teams when utilizing their parts Overall, their wiki describes their methods relatively clearly without getting too much into the details, and the methods they use are appropriate. Thus, their model also provides a good example to others.



OUC-China 2013

http://2013.igem.org/Team:OUC-China

Team **OUC-China 2013** (http://2013.igem.org/Team:OUC-China) performed a simulation of the behavior of bacteria with an artificial magnetic organelle in a magnetic field. Their model was novel, and noteworthy for its direct comparison to real data from their experiments in a microfluidic device. The model and the data were also used to generate a general equation for magnetobacteria behavior in a magnetic field (see graphs).



KU Leuven 2013

http://2013.igem.org/Team:KU_Leuven

KU Leuven 2013 (http://2013.igem.org/Team:KU_Leuven) used their model not only to describe what was happening on the order of a single cell, but also on the order of a colony - influencing their design and probing the robustness of their oscillator. Perhaps more impressively, they also considered the functionality of their devices in the crop farming environment that they were designed for.

This model was used to determine the efficacy of their device and to better evaluate its potential impact.

Let's consider the rubric specifically as it relates to this team's model.

KU Leuven performed (**flux balance analysis**) using the COBRA Toolbox solved a system of ordinary differential equations **ODEs** (http://2013.igem.org/Team:KU_Leuven/Project/Oscillator/Modelling) by searching through a reasonably broad parameter space, and considered **physical convection** (http://2013.igem.org/Team:KU_Leuven/Project/Modelling/Ecosystem_Level) of their pheromone product in a farming environment. They applied a wide variety of techniques to various aspects of their system, and did so very effectively. Their parameters come from the research and, when they are unknown, the team is up front about having estimated them (or searched a reasonable parameter space for them).

Their flux balance analysis was used to determine culture conditions to maximize production, while the ODE was used to consider synchronization of oscillating cells that begin out of phase. The models were not merely constructed; they were used to answer specific questions about the system. The practical results of their convection model are less clear, because of the number of unknowns, but the team lets us know that they have not made measurements for many of these parameters, and uses the model instead as a "back of the envelope" exploration of the usability of the system.

The results of their flux balance analysis were compared with experimental data gathered by the team. Flux balance analysis and solving a system of ODEs are nothing new to iGEM, but this team did a remarkably thorough job of both, and took care to use these models to answer legitimate questions about their project, rather than throwing up a bunch of disconnected models; modeling for the sake of producing graphs.

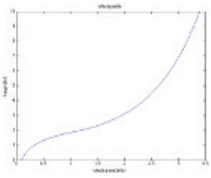


Figure 1 I Wind profile for a crop height of 2 m and a wind speed of 3.39 m/s at a height of 10 m.

Wind speed

Because of friction and obstacles on the earth's surface, wind speed varies with altitude. Generally, the velocity increases with increasing altitude. **A logarithmic wind profile is appropriate for the part above the crops** (Goudriaan, 1977, p. 96). The formula for this profile is

$$u = \frac{u*}{k} \cdot ln\left(\frac{z-d}{z_0}\right)$$

with u representing the velocity. Here d accounts for an upward shift above a vegetative cover. The relation $d=0.63 \times z_c$ is suggested, where z_c is the height of the crops. The length z_0 is called the roughness length and is often supposed to be about one tenth of z_c.

Colombia Uniandes 2013

http://2013.igem.org/Team:Colombia_Uniandes

Analysis of gene expression using systems of ordinary differential equations is not unusual in iGEM. Stochastic modeling of the same equations is less common, though by no means rare. **Colombia Uniandes 2013** (http://2013.igem.org/Team:Colombia_Uniandes) used both methods to create their model.

While their approach was not unique, they distinguished themselves by careful consideration and research of their model parameters - citing each and lending credence to the validity of their model. (In iGEM, as in life, one encounters many models composed almost entirely of educated guesses masquerading as parameters.) This approach provides a good example for others.

Parameter	Value Deterministic	Units Deterministic	Value Stochastic	Units Stochastic
Diffusion rate of Nickel	0.5034	1/min	0.5034	1/min
Dynamic constant for the entrance of nickel to the cell	4.63E-05	nM (nick)/(nM (HoxN)*min)	4.63E-05	molec (nick)/(molec (HoxN)*min)
Porine maximum expression rate	0.166	nM/ min	1.00E-01	molec/min
Association constant for DNA-RcnR complex	276	nM	1.66E+02	molec
Association constant of RcnR-Ni	21-29	nM	1.51E+01	molec
Repressor basal production rate	0.1	nM/min	6.02E-02	molec/min
Repressor destruction rate	1/1200	1/min	8.33E-04	1/min
Rate constant for the formation of the tetramer	0.82		8.20E-01	
Tetramer destruction rate	1/1200	1/min	8.33E-04	1/min
Cooperation	1.5-4	N/A	1.5-4	N/A
Porine basal production rate	0.031	nM/min	1.87E-02	molec/min
Porine destruction rate	1/1200	1/min	8.33E-04	1/min

Table 1. Parameters of the Deterministic and Stochastic Simulation

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:

1. **Could the measurement(s) be repeated by other iGEM teams?**
2. **Is the protocol well described?**
3. **Is it useful to other projects?**
4. **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 came before and to think about what can be done to improve upon existing methods. This information should be clearly stated on their wiki, and the team should convince you that they did due diligence when considering their measurement approach.

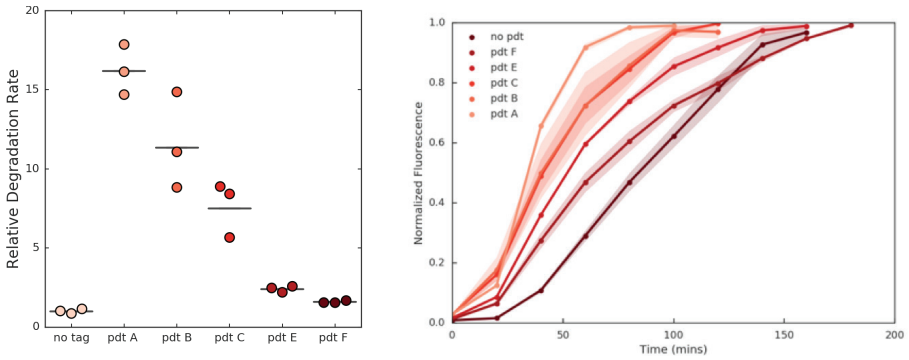
Let's look at some measurement examples from previous years:

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)

CASE 13A

TUDelft 2017

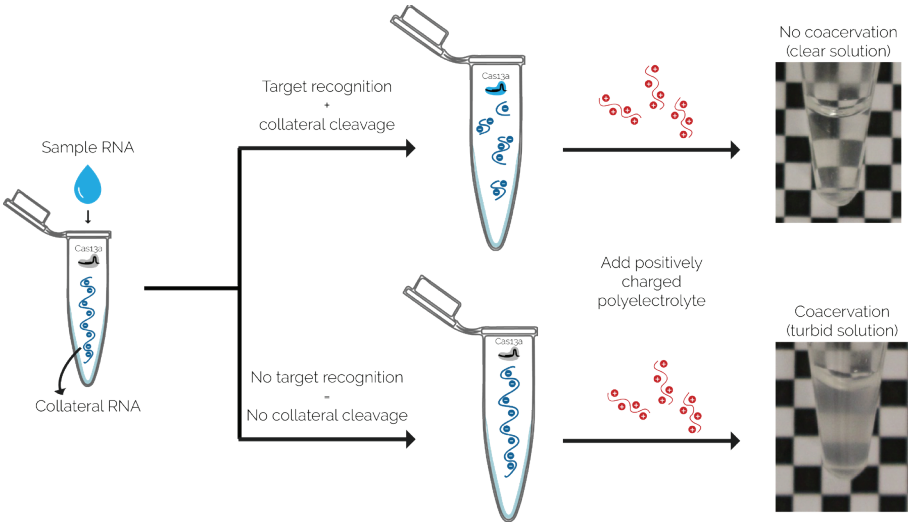
http://2017.igem.org/Team:TUDelft

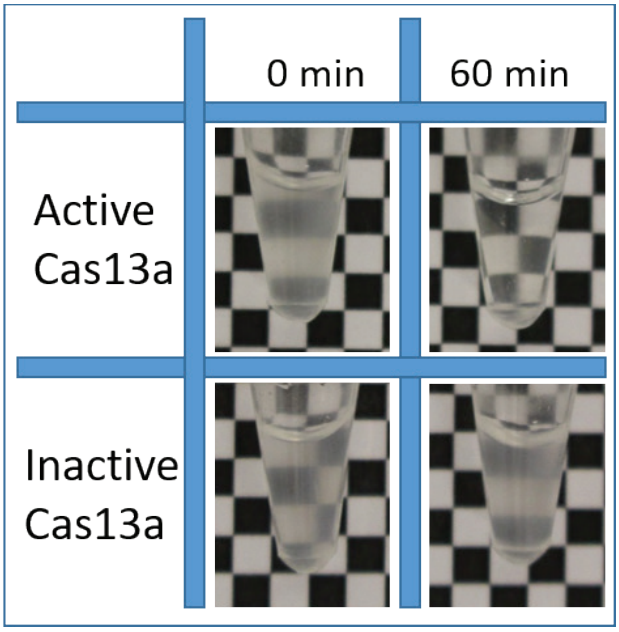
An important aspect of team TUDelft's portable on-site diagnostic assay for antibiotic resistance was to have a simple readout that did not require complex equipment or training. They developed a clever opacity-based readout called CINDY Seq that can be interpreted with the naked eye, and validated its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


Sample RNA
Collateral RNA
Target recognition
+
collateral cleavage
No target recognition
-
No collateral cleavage
No coacervation
(clear solution)
Add positively
charged
polyelectrolyte
Coacervation
(turbid solution)


0 min
60 min
Active
Cas13a
Inactive
Cas13a

Supporting Entrepreneurship

Summary

- The Best Supporting Entrepreneurship special prize is for teams who have explored the entrepreneurial side of synthetic biology.
- Successful teams will have constructed a formal business plan based on customer needs and created a viable product that customers want to use.

The focus of this prize is on ideas taken from lean Launchpad and customer discovery. In other words, teams are encouraged to go speak to potential customers during the initial design phase of their project. The reason for this emphasis on customer discovery is that customer-focused approaches correlate well with business success to a higher degree than teams working solely on business plan and pitch competitions.

The Supporting Entrepreneurship special prize is judged according to the following aspects:

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

Giving teams the opportunity to work on commercialization as part of their project could incentivize some teams to continue their work after the Jamboree. Teams may even consider applying to an incubator or accelerator after iGEM. The aim with this prize is to create the opportunity space and see what happens.

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

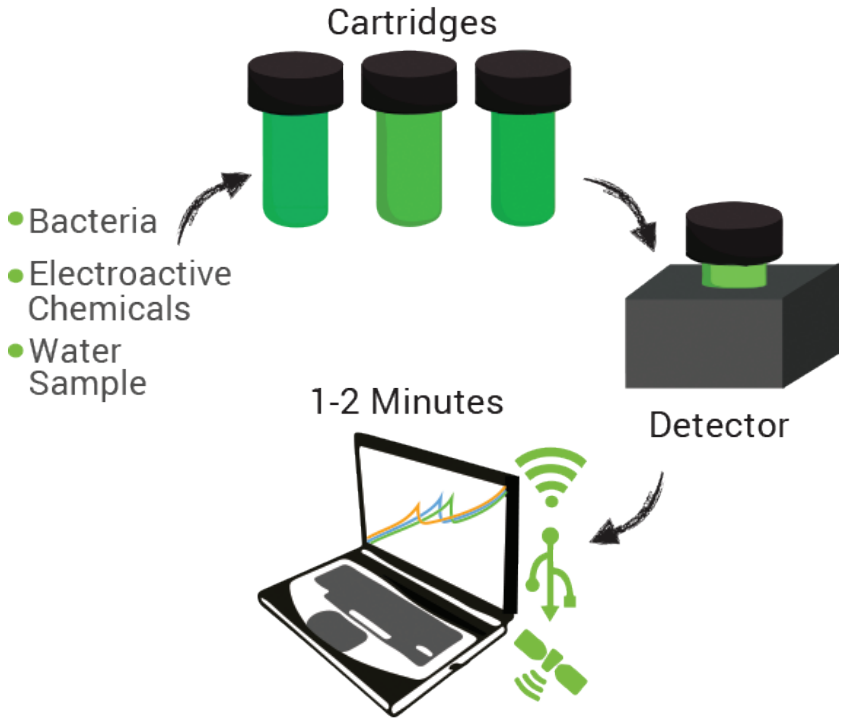
Calgary Entrepreneurial 2013

http://2013.igem.org/Team:Calgary_Entrepreneurial

FREDsense was the **2013 Calgary Entrepreneurship** (http://2013.igem.org/Team:Calgary_Entrepreneurial) team project. This project was continued from the 2012 North America regional championship award-winning Calgary project, with a focus on commercialization. The team focused on building their environmental toxin sensor into a product that was adapted to address pollution concerns surrounding shale oil production in Northern Alberta.

Before attending the Jamboree, they filed a provisional patent to protect their ideas against disclosure in a public forum, showing forethought in terms of IP strategy.

The team won the Entrepreneurship division in 2013 and went on to build a business after the Jamboree. It is not clear how much they talked with customers or had letters of intent to purchase functional prototypes of production units of their sensor before the 2013 Jamboree.

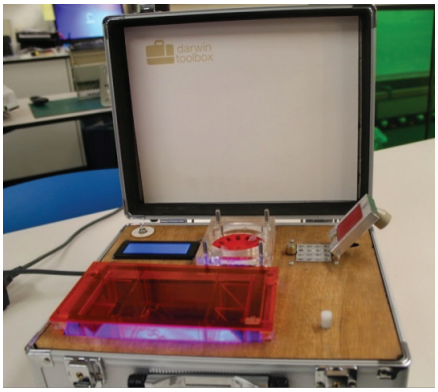


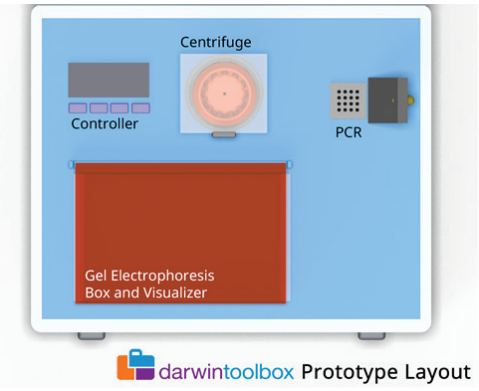
UCL 2013 E

http://2013.igem.org/Team:UCL_E

Another excellent example is the Darwin Toolbox, a hardware project presented by the **2013 UCL iGEM entrepreneurship team** (http://2013.igem.org/Team:UCL_E) They wanted to address lack of widely available synthetic biology tools by making a cheap, safe, user-friendly lab-in-a-box for high schools and community labs

They built a functional prototype lab and brought it to the Jamboree, but it was unclear if they had incorporated user feedback into their device by the time of the Jamboree or if they had any committed customers. After coming across some trademark issues, Darwin Toolbox rebranded as **Bento Bio** (**https://www.bento.bio/**) and have continued to work on their project. In 2015, the project was successfully funded on Kickstarter to launch mass production.





Software Tool

Summary

- Software tools are often created by parts-based (wetlab) teams to support a need in synthetic biology.
- Excellent tools should be both novel and useful to others in the field, aiding some part of wetlab project design or execution in various types of projects.
- The software should be user-friendly and have good documentation.

Teams can generate software that goes on github, so if you don't feel comfortable, please get in touch so that the Judging Corps Committee can help you find a judge with technical software competency to help you evaluate the project.

However, teams applying for the software tool award should have built something that can be used and evaluated by non-experts, so please take this into consideration during your evaluation. The purpose of this award is to make something that other teams can use.

The software tool rubric is as follows:

1. **How well is the software using and supporting existing synthetic biology standards and platforms?**
2. **Was this software validated by experimental work?**
3. **Is it useful to other projects?**
4. **Does the team demonstrate that their software can interface with and be embedded in new workflows?**
5. **Is the software user-friendly and well documented?**

Let's look at one example of a great software tool:

Valencia UPV 2016

http://2016.igem.org/Team:Valencia_UPV/Software

The software tool, as described by the team:

"In order to ease the use of HYPE-IT we have developed a web application. Its two pillars are: a database which has genomic information related in a cause-effect way with the phenotypic trait regulated by that gene, and a scoring which returns to the user all possible gRNAs of that gene, from highest to lowest score. Given a gene, the scoring system returns all possible gRNAs with their associated scores and primers for Goldenbraid standard. Our scoring algorithm has been developed from laboratory studies and criteria accepted by scientific community, being our best target always within the top 5 suggested by other tools commonly used. Usability has been a priority in the web design.

It includes techniques such as routing by the standard REST and web design standards, including a template externally developed. Thus, we have created not only a technical tool, but also a user-friendly online collaborative network."

The team's Hack Your Plants Editing with Innovative Technologies (HACK-IT) project was about making plants easier to engineer using simplified CRISPR Cas9 tools. The team developed a split Cas9 system to bypass the issue of transforming a single huge coding sequence into plants.

This viral approach allows delivery of the editing machinery and guide RNAs (gRNAs) to the plant without the use of agrobacterium-mediated transformations.

The software component of the project allows the optimal gRNAs to be selected from a database of different plants and genes.

Like many software teams, Valencia have created an external website where judges and the public can access their work: hypeit.cloudno.de (note: URL is no longer functional).

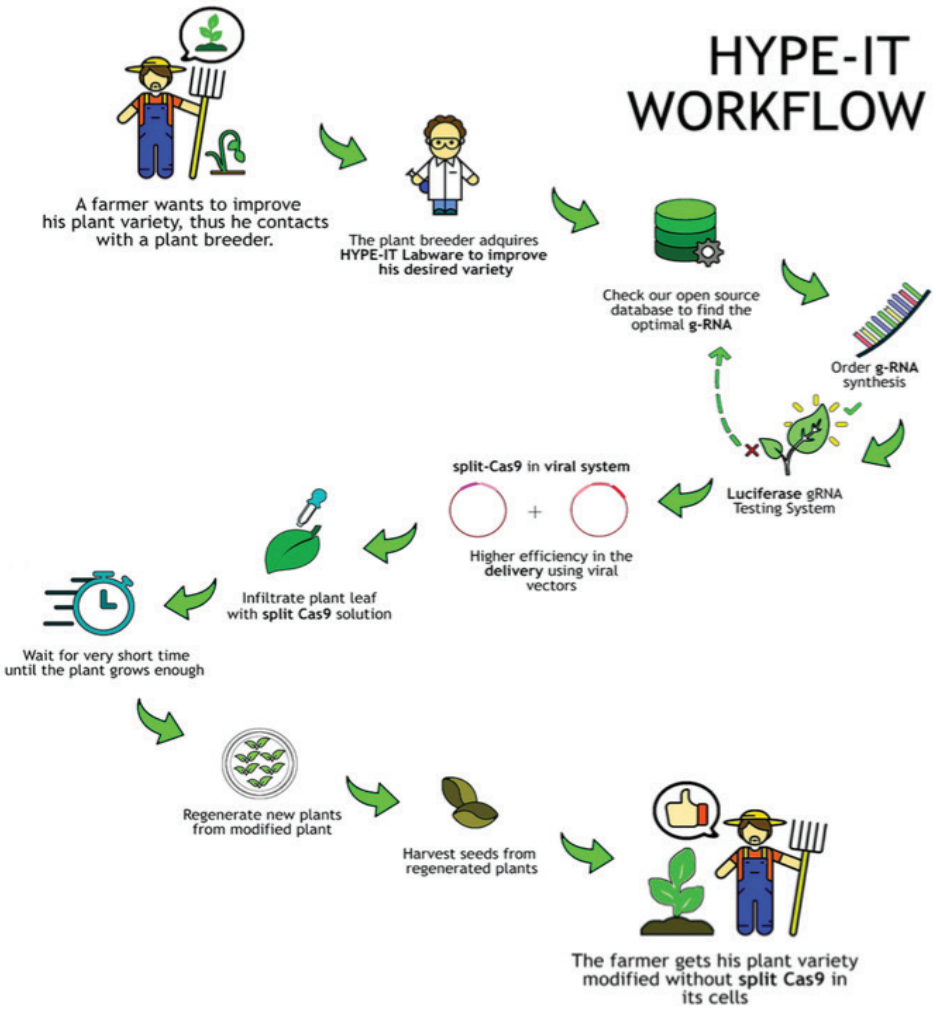
While iGEM generally penalizes teams for hosting content off the iGEM servers, the software tool is one award where this is acceptable, as many teams need to implement software frameworks that cannot be installed on the iGEM servers.

In terms of the software, the team scored very highly in every category, with the exception of **aspect 5**.

This may be because users need to register to use the program, and the team may not have been responsive to the judges in the weeks coming up to the Jamboree, or the judges may not have registered to use it. Judging feedback on this issue also mentioned a lack of adequate documentation and explanations on the wiki.

The HYPE-IT software makes use of a database of guide RNAs that integrates well into synthetic biology and iGEM by the use of a Phytobrick parts collection. These parts allow users to perform their own plant transformations using CRISPR on a number of plant chassis. Creating a part collection and characterizing this collection also satisfies the experimental validation criterion.

The team also thought about how to make this tool a part of new workflows, as shown by their workflow diagram.



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 Jamborees. The Hardware special prize was introduced to reward non-Hardware Track teams who also took the time and effort to develop a unique piece of synthetic biology-related hardware. As with all special prizes, the Hardware special prize winner will be determined by a specific section in the judging ballot, where the language is tailored more exactly to the nature of the prize.

In the case of the Hardware special prize, the aspects are as follows:

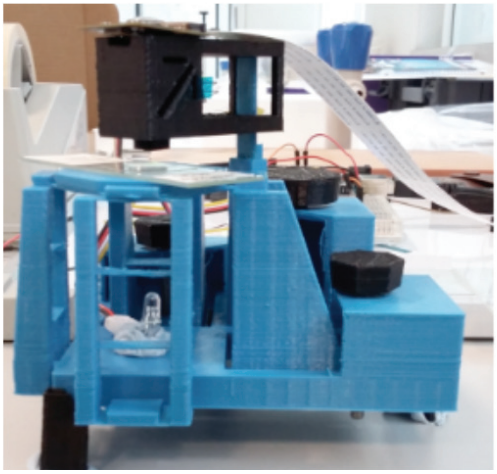
1. **Does the hardware address a need or problem in synthetic biology?**
2. **Did the team conduct user testing and learn from user feedback?**
3. **Did the team demonstrate utility and functionality in their hardware proof of concept?**
4. **Is the documentation of the hardware system sufficient to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

Let's look at one hardware example:

Cambridge-JIC 2015

http://2015.igem.org/Team:Cambridge-JIC

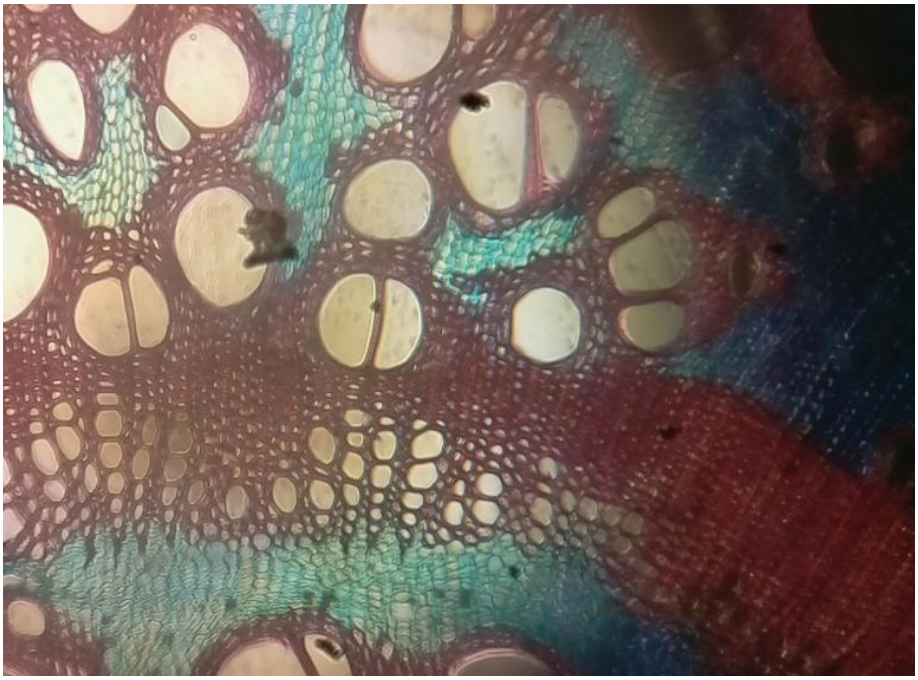
Cambridge-JIC developed an open-source, low-cost, 3D printed microscope based on a Raspberry Pi computer and camera named the "Openscope". It can be difficult to get access to microscopes, so the problem they chose to solve is creating a low-cost variant that almost anyone can build for their lab using easily available materials and 3D-printing files. They designed several versions of their scope: manual, GFP, and motorized stage.



Cambridge-JIC worked hard to create a comprehensive **bill of materials (BOM)** http://2015.igem.org/wiki/images/d/d0/CamJIC-OpenScope-BOM.pdf as well extensive **documentation with 3D printing files** http://2015.igem.org/Team:Cambridge-JIC/Downloads so that others can assemble materials to easily reproduce the device.

Although they did a good deal of testing on their own (including using biological samples from other teams), one way in which they could have strengthened their project would have been to see how well others would be able to use their design and instructions, and use resulting feedback to improve the scope.

Regardless of this, however, the utility and functionality of their prototype can be clearly seen in the brightfield image shown here.



Plant Synthetic Biology

Summary

- This award is designed to celebrate exemplary work done in plant synthetic biology. This award could also be given to a team working with algae or another 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 tracks and as such, we are supporting plants as a special prize and not a track. Teams have created parts from multiple plant chassis and we have a collections page on the Registry with more information: http://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 or algal cell?**
2. **Does their work address a need or problem in plant synthetic biology?**
3. **How well did the team use the special attributes of the plant chassis?**
4. **Are the parts/tools/protocols for plants made during this project useful to other teams?**

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

Cambridge-JIC 2016

http://2016.igem.org/Team:Cambridge-JIC

The Cambridge-JIC 2016 team built a toolbox for chloroplast transformation and worked on optimizing the transformation protocol for Chlamydomonas reinhardtii, which is a single celled chlorophyte useful for synthetic biology applications as it has very efficient protein expression compared to other systems. During the course of their work, the team built a library of tested parts optimised for Chlamydomonas and related chloroplasts to facilitate the assembly of synthetic constructs using the PhytoBricks standard. Research in the chloroplasts of microalgae, such as Chlamydomonas reinhardtii, is likely to be applicable to studies of other plants. They also built an inexpensive gene gun and growth chamber and designed a tool which could help achieve essential homoplasmy (transformation of all copies of chloroplast DNA) in one generation instead of 2-3 months of selection.

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 for short).
- 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 SDG prize is built on top of success in other areas of iGEM's judging, particularly Human Practices.
- Since the SDGs are built on a holistic understanding of what it takes to solve today's grand societal challenges, which 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 teams' 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. And in so doing, it instructs teams on the necessity of taking a transdisciplinary approach – i.e. approaches that enroll resources from multiple disciplinary perspectives, as well as from ones outside 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 utilize the **UN SDG Partnership Platform** https://sustainabledevelopment.un.org/partnership/browse/#, where you can search for current and past projects from across the globe addressing the SDGs . You can search by 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.

Below is an example of a past iGEM team who won this prize:

Fudan 2020

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

The **Fudan 2020** (https://2020.igem.org/Team:Fudan) team explored three SDGs in their work on creating a sustainable calcium supplement to help people suffering 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 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 where they combined performance art with education and promotion of physical activities targeted at seniors, with the aim of promoting healthy lives and well-being (SDG 3).

Inclusivity Award

Summary

- The Inclusivity Award is for teams who have explored ways to make scientific research inclusive of people with diverse backgrounds and identities, for iGEM, synthetic biology, or STEM more broadly.
- Successful teams will have researched barriers that prevent under-represented 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 the work thoughtful about inclusivity and local public values in its implementation?**
4. **Is the work documented in a way that other teams or external entities can build upon?**

This special award is a new prize in iGEM that 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. While this is a new award and rubric, some previous iGEM teams have strongly embraced this philosophy and demonstrated exceptional exploration of these issues.

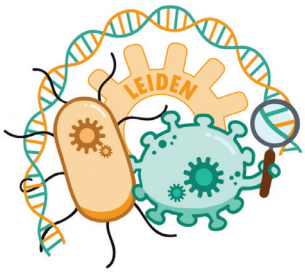
Let's look at examples of great inclusivity projects:

Rochester 2020

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

Team **Rochester 2020** (https://2020.igem.org/Team:Rochester) 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, Lithuianian, 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 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.

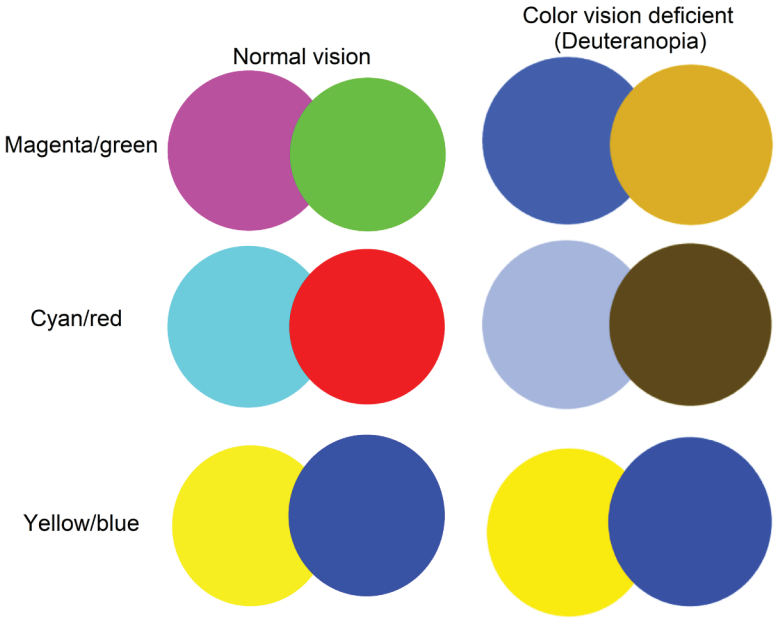


Leiden 2020

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

Team **Leiden 2020** (https://2020.igem.org/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.

Visible for all | Color-blind only



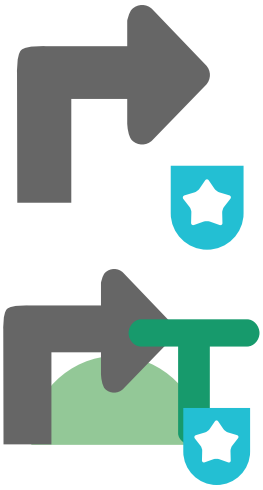
The team recommended that color-blind persons should find assistive tools to better discriminate colors in publications that are not color-blind friendly.

PYMS GZ China 2020

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

Increasing the visibility of minorities in STEM is a powerful instrument toward changing the social and cultural contexts that fuel their under-representation. In their podcast series "Boss Women in STEM," **PYMS GZ China 2020** (https://2020.igem.org/Team:PYMS_GZ_China) interviewed formidable women in STEM about their work and their paths to success, shedding light on the struggles they faced along the way.

Additionally, PGMS GZ China consulted prominent Latinx experts in STEM on the topic of Latinx underrepresentation, after which they created a Diversity and Inclusion Plan for the Latinx Community in STEM. Their plan described steps that could be taken to address discrimination, lack of visibility, communication and opportunities, as well as the lack of STEM resources faced by Latinx youth. In their work, PYMS GZ China exemplified iGEM's spirit of diversity, inclusivity, outreach, and collaboration.



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 (automatically checked by the Judging Form)
- 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 the 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 five aspects for assessment that you should keep in mind as you evaluate Basic and Composite Parts:

Best Basic Part aspects:

1. **How does the documentation compare to BBa_K863006 http://parts.igem.org/Part:BBa_K863006 and BBa_ K863001 http://parts.igem.org/Part:BBa_K863001?**
2. **How new/innovative is it?**
3. **Did the team show the part works as expected (modeling data can be acceptable)?**
4. **Is it useful to the community?**
5. **How well characterized (experimentally measured or modeled) is this Basic Part when tested in a device?**

Best Composite Part aspects:

1. **How does the documentation compare to BBa_K404122 http://parts.igem.org/Part:BBa_K404122 and BBa_ K863005 http://parts.igem.org/Part:BBa_K863005?**
2. **How new/innovative is it?**
3. **Did the team show the part works as expected (modeling data can be acceptable)?**
4. **Is it useful to the community?**
5. **How well characterized (experimentally measured or modeled) is this Composite Part?**

To satisfy Registry 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 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.

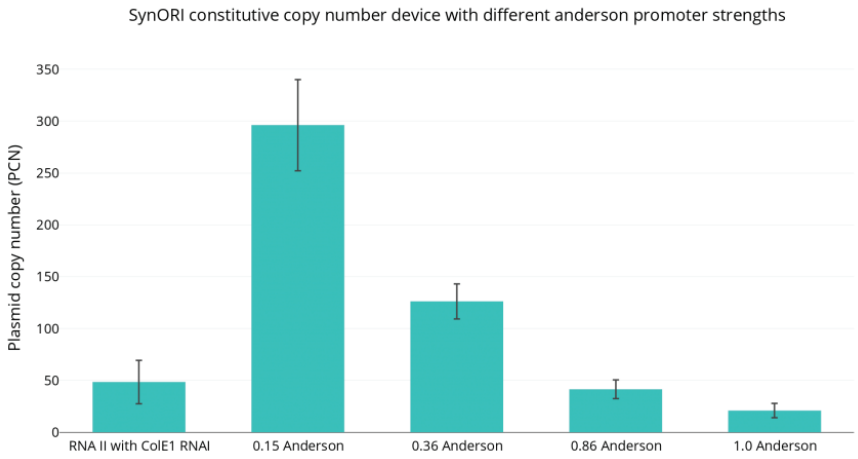
From the perspective of creating a Registry that can be used long-term by scientists and engineers in the community, common issues with part documentation include:

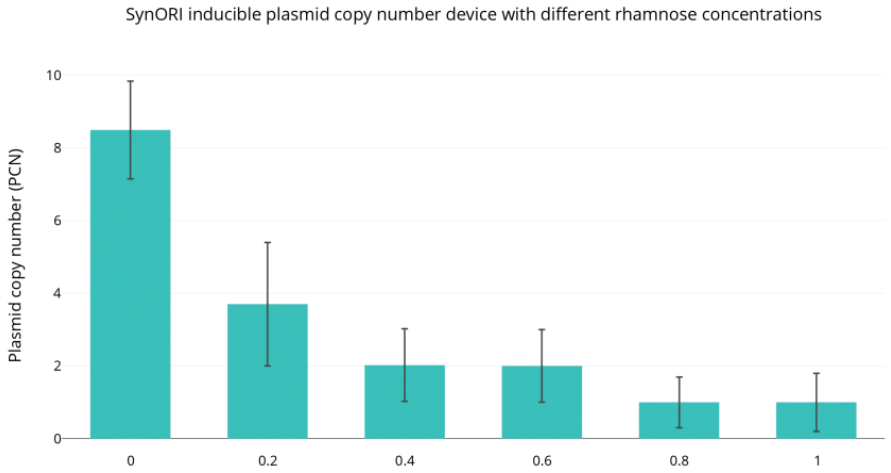
- Figure axes and legends lacking important details about how the data was obtained (e.g., experimental design details, including strain and expression plasmid for protein-coding parts); the data on the Registry page should be able to stand alone, if possible
- Links to UniProt or other database for original sequence or literature references not provided for parts derived from a natural or de novo sources
- Information about which test device, if any, was used on the Registry documentation page (including relevant part numbers) to generate characterization data for parts. This is most commonly seen for Basic Parts.

Basic Part Example

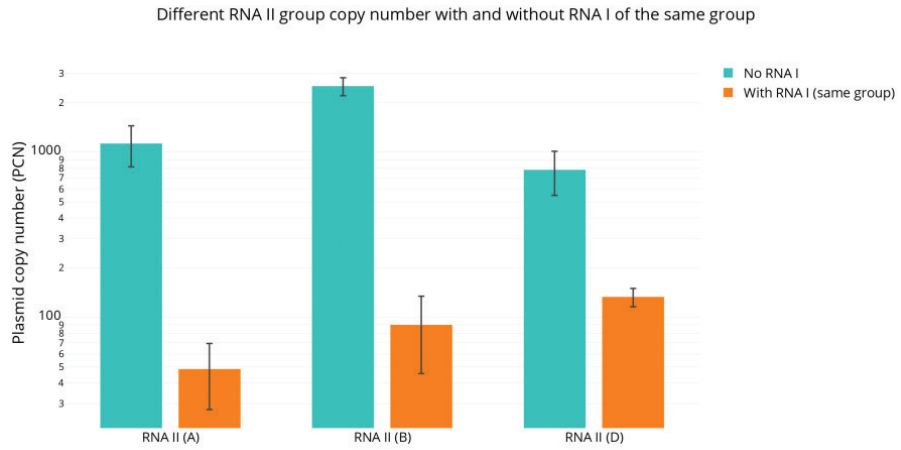
BBa_K2259000: http://parts.igem.org/Part:BBa_K2259000

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 (SynORI) which 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 undergrad section http://2017.igem.org/Team:Vilnius-Lithuania/Part_Collection. The team have extensively documented their Part on the Parts Registry. They give an overview of the basic biology of plasmid replication and, 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 a constitutive manner and also they showed that the plasmid copy number could be controlled in an inducible manner.

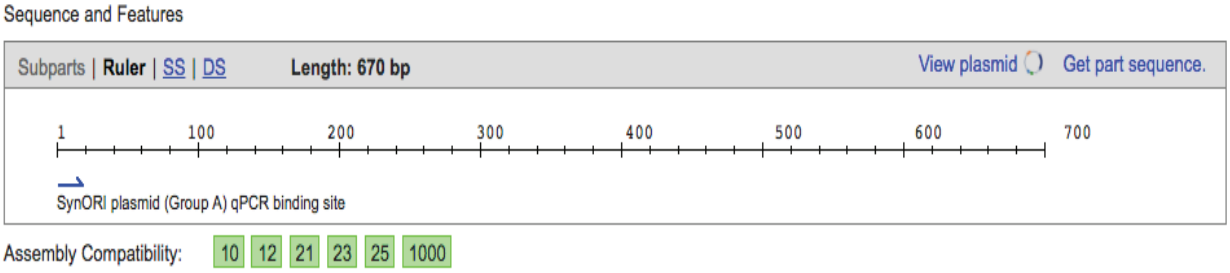




The team have also showed that that RNA I works specifically with RNA II with different groups of their synORI system to control the plasmid copy number as proof of concept.



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
http://parts.igem.org/Part:BBa_K863006
made by Bielefeld-Germany 2012

BBa_K863001
http://parts.igem.org/Part:BBa_K863001
made by Bielefeld-Germany 2012

Composite Parts Examples

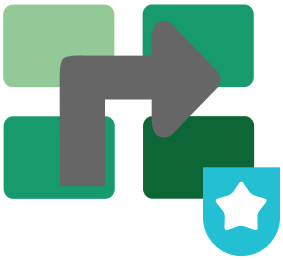
The aspects for Composite Parts are the same as for Basic Parts.

You may look at the examples for The Best Composite Parts for iGEM 2017 which are below:

BBa_K2259091
http://parts.igem.org/Part:BBa_K2259091
made by Vilnius-Lithuania, Undergrad Section

Part:BBa_K2306008
http://parts.igem.org/Part:BBa_K2306008
made by TUDelft, Overgrad Section

Part:BBa_K2206006
http://parts.igem.org/Part:BBa_K2206006
made by CLSB-UK, High School Section



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.
- A collection must contain at least 3 parts but there is no upper limit to the number of parts a team can create.

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:

1. **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?**
2. **How does the documentation compare to the BBa_K747000-095 collection?**
3. **Is the collection fully documented on the Registry so any user could use the parts correctly?**
4. **Did the team finish building a functional system using this collection?**
5. **Is it useful to the community?**

Part Collection Examples

Here are some great examples of Part Collections:

Vilnius-Lithuania 2017
http://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, however they all consolidate for a common purpose of creating a flexible and precise multi-plasmid system.

Part Range: BBa_K2259000 - K2259080

Arizona State 2016
http://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

Peking 2015
http://2015.igem.org/Team:Peking/Part_Collection

The Peking 2015 team combined the specific sequence binding activity of dCas9 with diverse characteristics of split enzymes, thus creating a part collection named “PC Reporters Collection”.

Part Range: BBa_K1689007 - K1689020

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.

The wiki is the very first thing a judge sees when assessing one of their assigned teams, as the wiki evaluation occurs before the 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 judging body. There are four 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 evidence?**
3. **Is the wiki well designed, functional, and easy to navigate?**
4. **Will the wiki be a compelling record of the team's project for future teams?**

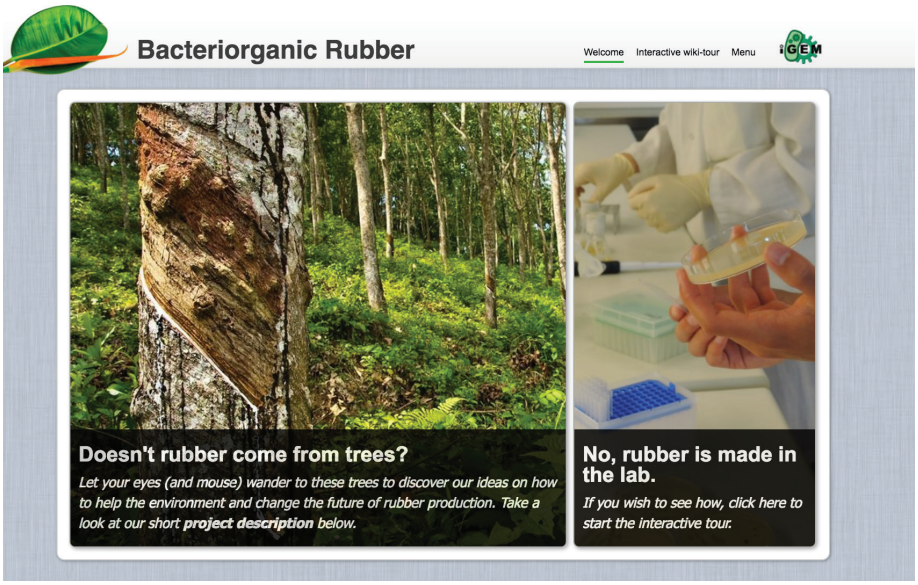
Let's look at one example of a winning team wiki:

SDU-Denmark 2013

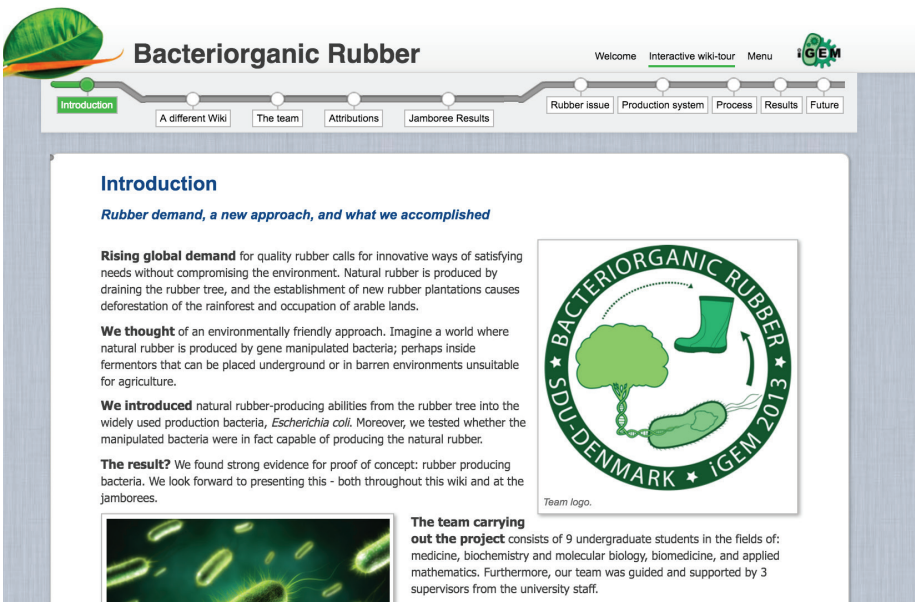
http://2013.igem.org/Team:SDU-Denmark

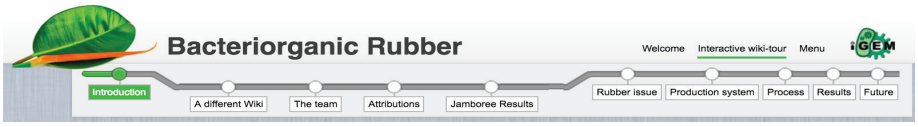
Looking at the front page for the SDU-Denmark wiki, we can see that the color scheme and layout is visually appealing. It is formatted in such a way that the eye is drawn to the critical information – in this case, the motivation and basic idea behind their project: making rubber using bacteria instead of trees.

We also see an invitation to join an interactive tour of their project. While this type of feature is not required and is not necessarily standard, it allows the team to tell their story in the most advantageous manner possible.



If we start the tour, we are taken to the image on the next page.





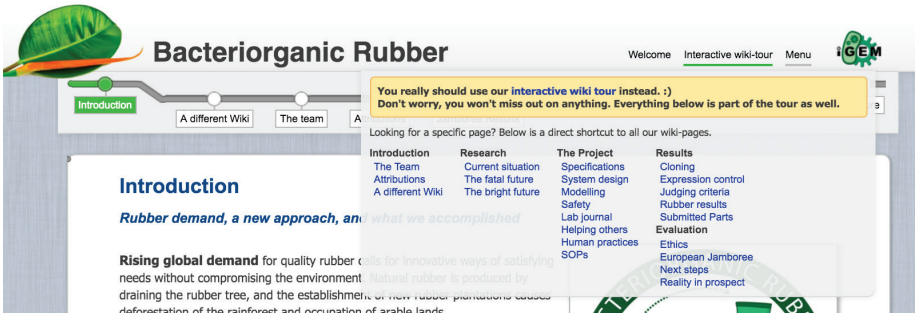
Navigationally, this wiki also allows a viewer to easily jump to any particular section of interest by hovering over the “Menu” link.

The ease of navigation of this wiki is just one characteristic that makes it deserving of the Best Wiki award. If we look more into the “guts” of the wiki, we find a wealth of information about the project, including in-line links to their references (reached by hovering over the speech bubble icons).

The information is laid out in a way that is visually easy to read and uses language that is easy to understand. In the results section, we find detailed descriptions of their entire experimental process, including dozens of publication-level figures that can be opened up in-screen for more detail.

SDU-Denmark made such a remarkable attempt at ensuring their wiki was of the highest standard for the 2013 Jamboree, that they won the best wiki award again in 2014 with the same design! The attention to detail, layout, navigation and ease of use make their design one of the most compelling wiki records in the brief history of iGEM.

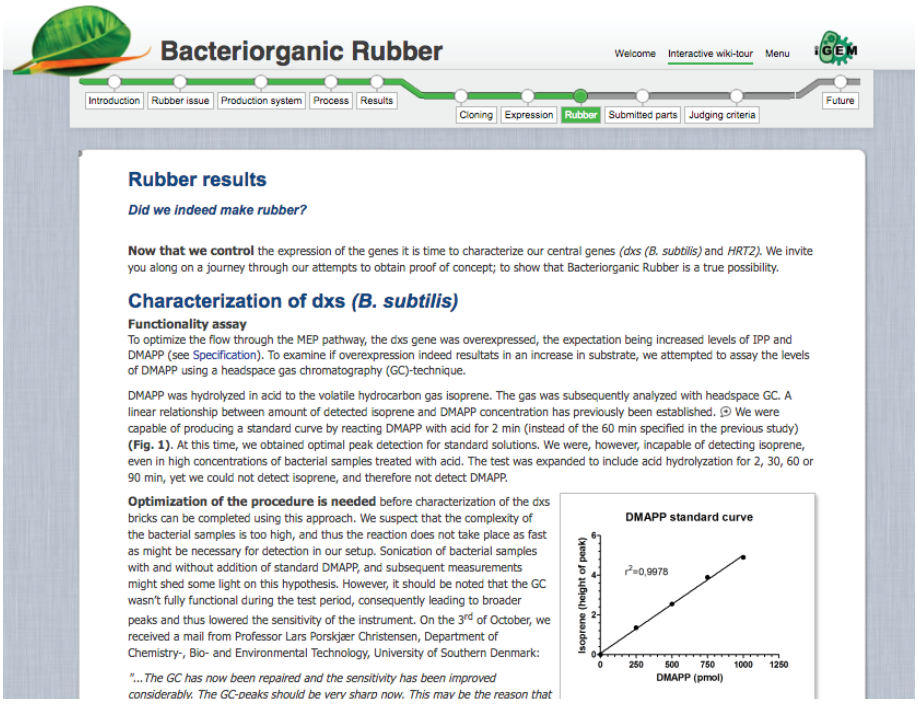
Finally, it is important to note that this wiki also follows all of the iGEM wiki requirements (e.g., all pages, images, and files are hosted on the iGEM server, NO flash, NO iframes etc). If any content is hosted off-site, the wiki is automatically disqualified from the Best Wiki award (as well as any medals). The winning wiki is the first wiki that teams will look at in subsequent years, so it must be the best example in every way.



We can see why this wiki earned high marks in all of the judging aspects. However, this wiki has some additional characteristics that facilitate judging for other categories in the rubric: (1) a page listing their accomplishments in terms of medal criteria and (2) direct links to their BioBricks in the Registry of Standard Biological Parts.

Although these pages do not necessarily correspond to any of the aspects for wiki assessment, they can be very useful to a judge before, during, and after a team’s presentation when they are looking for the answers to specific judging questions. The availability and organization of the information reflects well on the team project as a whole.

Finally, SDU-Denmark also makes their wiki source code available to all teams, demonstrating the sense of worldwide camaraderie and collaboration that is so important in iGEM.



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 20 minutes long, which will be viewable to judges before the Jamboree.
    - This was a new format for 2020. Please keep in mind that teams will have varying levels of video production expertise.
- Excellent presentations will be engaging, easily understood by a broad audience, balance big-picture ideas with design details, and flow smoothly.

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 broad audience. 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 does the presentation communicate the team's project and their goals?**
2. **Do the presentation design elements effectively communicate the technical content?**
3. **Did you find the presentation engaging?**
4. **Were reference material and data acknowledged appropriately?**

In 2020, teams produced Presentation Videos for the first time in iGEM's history. Teams will continue to use videos to present their projects as iGEM moves forward, so let's take a look at one of the winning Presentation videos from 2020:

TUDelft 2020

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

You can watch the TUDelft 2020 Presentation video by going to the URL above or by scanning the QR code below.

Team **TUDelft 2020** (https://2020.igem.org/Team:TUDelft) produced an excellent example of an iGEM presentation. From clearly explaining the problem they explored to describing the pathways they used in their genetic devices with easy-to-follow figures, the 2020 TUDelft team showed how a video can be used to effectively present a complex project in 20 minutes. The team had multiple student team members present the project in a clear and engaging way. The team did not oversell their project, nor did they use distracting graphics or flashy elements to “sell” 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 was recognized for its excellence in clear science communication, use of various design elements, and audience engagement.

CHAPTER 5

High School Teams

Introduction

- High School teams are considered a separate section of iGEM, just like the distinction between the Overgrad and Undergrad sections.
- All High School teams will be evaluated just like any other Track teams, with the exception being that High School teams cannot choose a track distinction (e.g., energy, environment). As such, they are also treated as their own Track.
- 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 written 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, and shorter working hours, not to mention the fact that the students probably haven't taken any college-level courses yet! As a result, it can be considered a substantial achievement for a high school team to make a functioning part.

This is not to say that high school teams are not able to make 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.

Let's look at two examples of winning High School teams:

TAS Taipei 2017

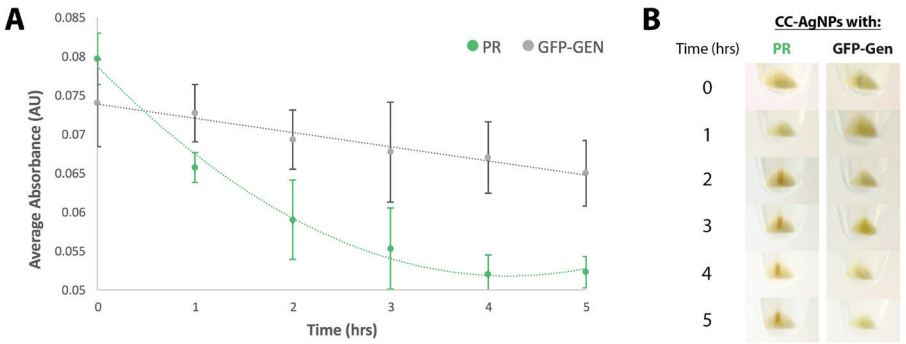
http://2017.igem.org/Team:TAS_Taipei

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.

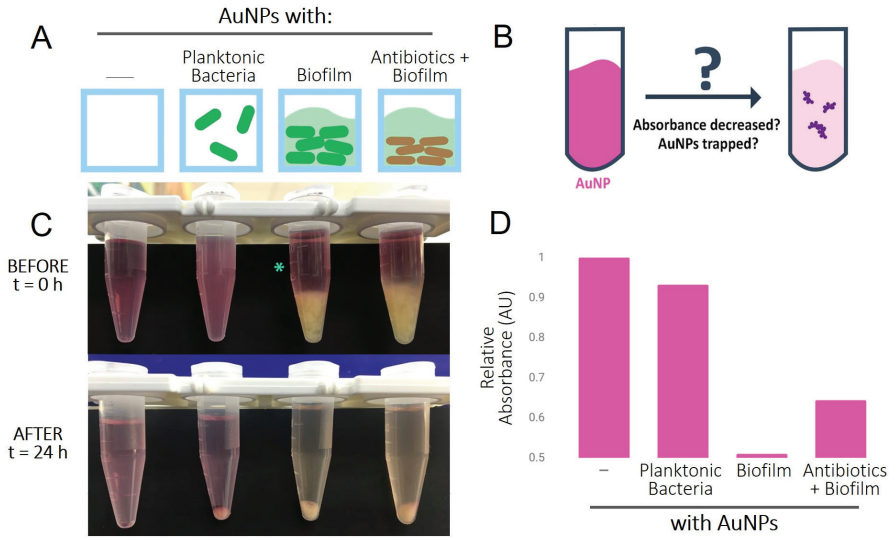
The team took a two-pronged approach in their solution to remove nanoparticles from wastewater:

1) Proteorhodopsin receptors 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



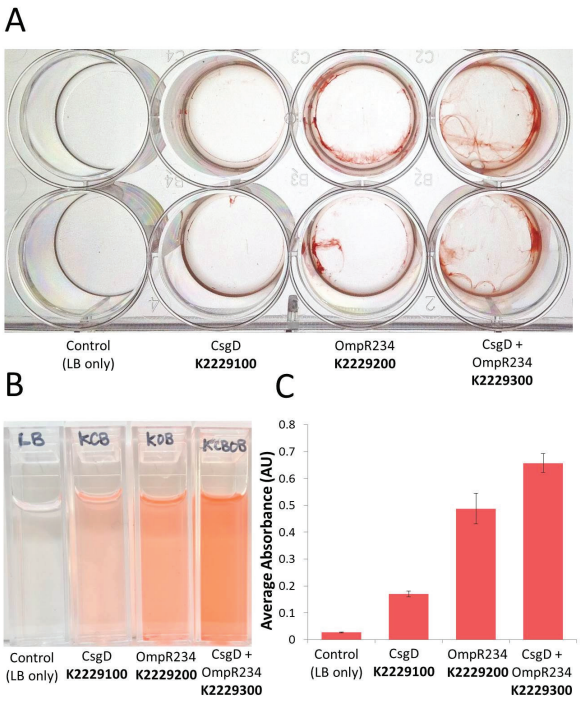
As seen in their experimental results, the strain containing PR shows a decrease in absorption relating to nanoparticle presence over time, and the cell pellets show an increased dark mark corresponding to nanoparticle collection. It is clear that this part works to bind nanoparticles from solution.

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).

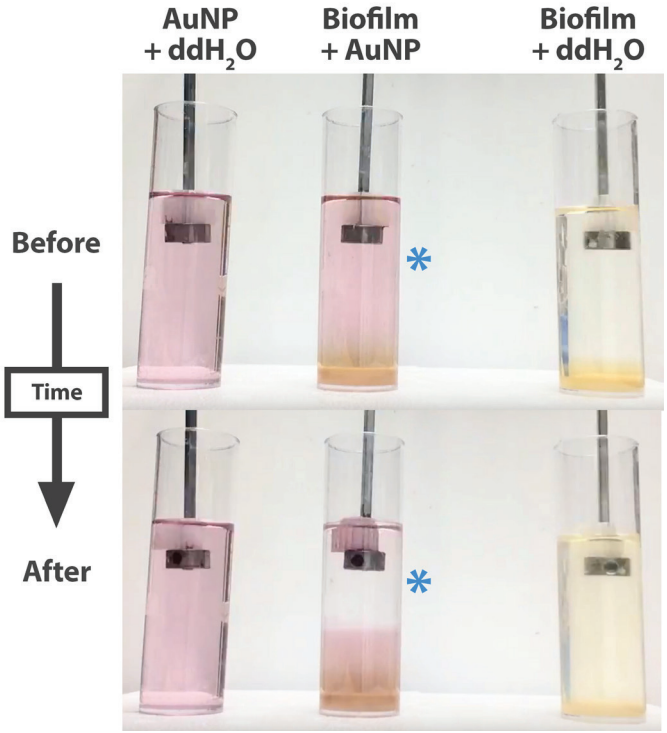


After verifying their idea, the team's next step was to design parts in *E. coli* that would enhance biofilm production. They decided to overexpress the curli operon using two different genes, csgD and ompR234. When expressed, these genes both successfully increased biofilm production, and the combination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



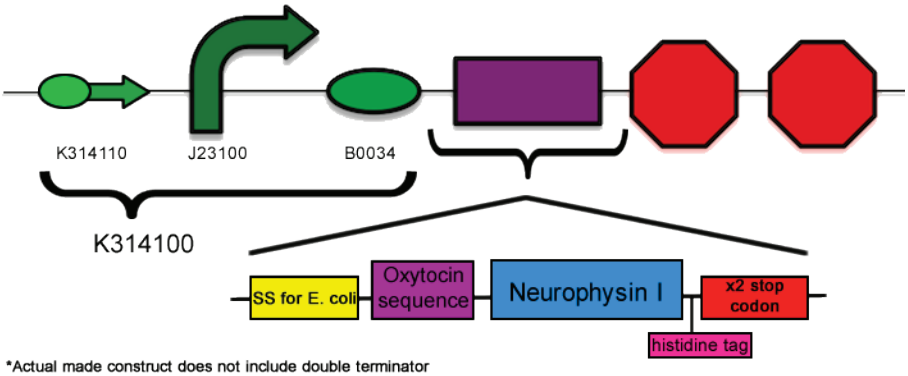
TAS Taipei demonstrated an impressive number of accomplishments, and did so with a high level of engineering design and scientific quality, as seen by their use of controls, proof-of-concept experiments, and prototyping. Furthermore, the project clearly works and, as seen in the figure captions throughout 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.

Lethbridge Canada 2013

http://2013hs.igem.org/Team:Lethbridge_Canada

Lethbridge Canada was the grand prize winner for the 2013 High School division competition. Their project aimed to produce a natural form of oxytocin and attach it to a carrier molecule to prevent the breakdown of oxytocin. Normally, oxytocin breaks down quite rapidly, making it difficult to use in the lab or as a therapeutic agent. This ambitious project was well received for two main reasons: thorough research and design of their two constructs and clear explanations of their methods and results.

The team designed two constructs. The first was to express the maximum amount of oxytocin, along with its carrier protein neurophysin I. The team modified their construct with both an *E. coli* signal sequence for extracellular export and a histidine tag for detection:



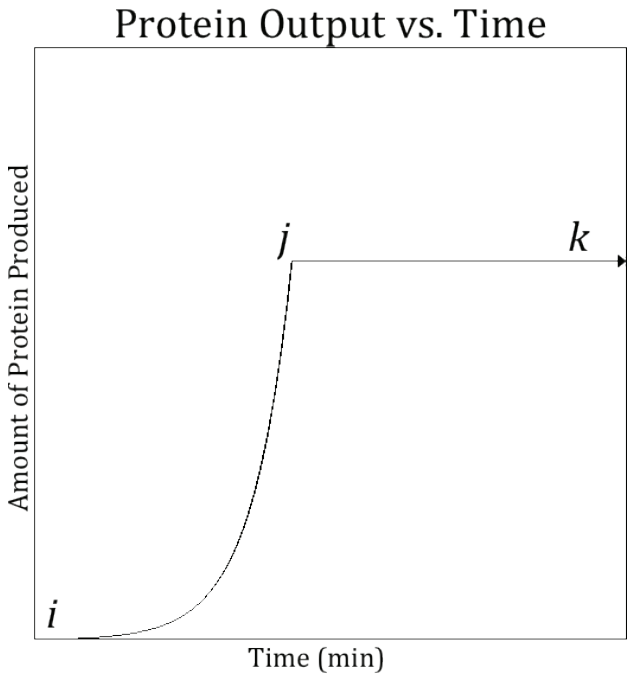
The team was able to completely clone this part, as shown by the experimental data http://2013hs.igem.org/Team:Lethbridge_Canada/results on their wiki. Even more impressive, the team was able to express the protein, as evidenced by a slot blot:

ANTI-HIS SLOT BLOT

Lane #	Contents
Lane 1:	100µL Oxytocin in 200µL TBS
Lane 2:	200µL Oxytocin in 100µL TBS
Lane 3:	250µL Oxytocin in 50µL TBS
Lane 4:	300µL Oxytocin
Lane 5:	25pM TruB-His positive control

Lethbridge Canada designed a second construct that would allow them to test many different promoters by combining them with mCherry. The idea of this construct was that it would give them a better idea of which promoter to use to maximize output of a secondary enzyme. Unfortunately, they did not have time to fully investigate the expression with different promoters. However, they used **mathematical modeling** (http://2013hs.igem.org/Team:Lethbridge_Canada/math) to help determine the correct promoter to use. Although the model is fairly basic, it is well documented and thoroughly explained on their wiki.

$$n_p = \begin{cases} \int_i^j \left(b_i 2^{\frac{t}{30\text{min}}}\right)\left[\left(\frac{4200\text{nt/min}}{l_{tgene}}\right)\left(\frac{1}{2}\right)^{\frac{t_s}{t_h}}\right]\left(\frac{12\cdot\text{RBS}}{7}\right)dt, i \le t \le j \\ \int_j^k \left(b_i 2^{\frac{j}{30\text{min}}}\right)\left[\left(\frac{4200\text{nt/min}}{l_{tgene}}\right)\left(\frac{1}{2}\right)^{\frac{t_s}{t_h}}\right]\left(\frac{12\cdot\text{RBS}}{7}\right)dt, j \le t \end{cases}$$



Furthermore, the team made extensive connections between their project and their community through a variety of Human Practices activities, including interviews with local health professionals, discussions with their school boards, and surveys of their parents' attitudes towards iGEM and their participation in it.

In conclusion, this project was successful for multiple reasons:

1. The team used thorough (and attributed) background research to design a novel, elegant system to produce biological oxytocin.
2. They successfully cloned and expressed one of their constructs, and they posted their sequences and designs to the Registry.
3. They performed mathematical modeling to describe how their system would function in vitro.
4. Their wiki, presentation, and poster were simple, clear, and to the point.
5. They connected their project to their community through multiple human practices projects.

In short, Lethbridge Canada 2013 completed all of the tasks normally associated with a successful parts- based iGEM project. Although the level of detail and complexity of the project are somewhat lower than most collegiate projects, the team was able to succeed in a number of difficult challenges (e.g., making a working part, using modeling in lieu of experimental work) and effectively communicate their project to a broad audience. These qualities made Lethbridge Canada a winning high school team.

Acknowledgements

Acknowledgements

We are excited to present this Handbook to the judges this year and hope that it will be a valuable reference for both veteran and new judges. This resource would not have been possible without the help of many of our contributors. We would like to thank everyone who has contributed their time and effort to writing content for this handbook over the last several years.

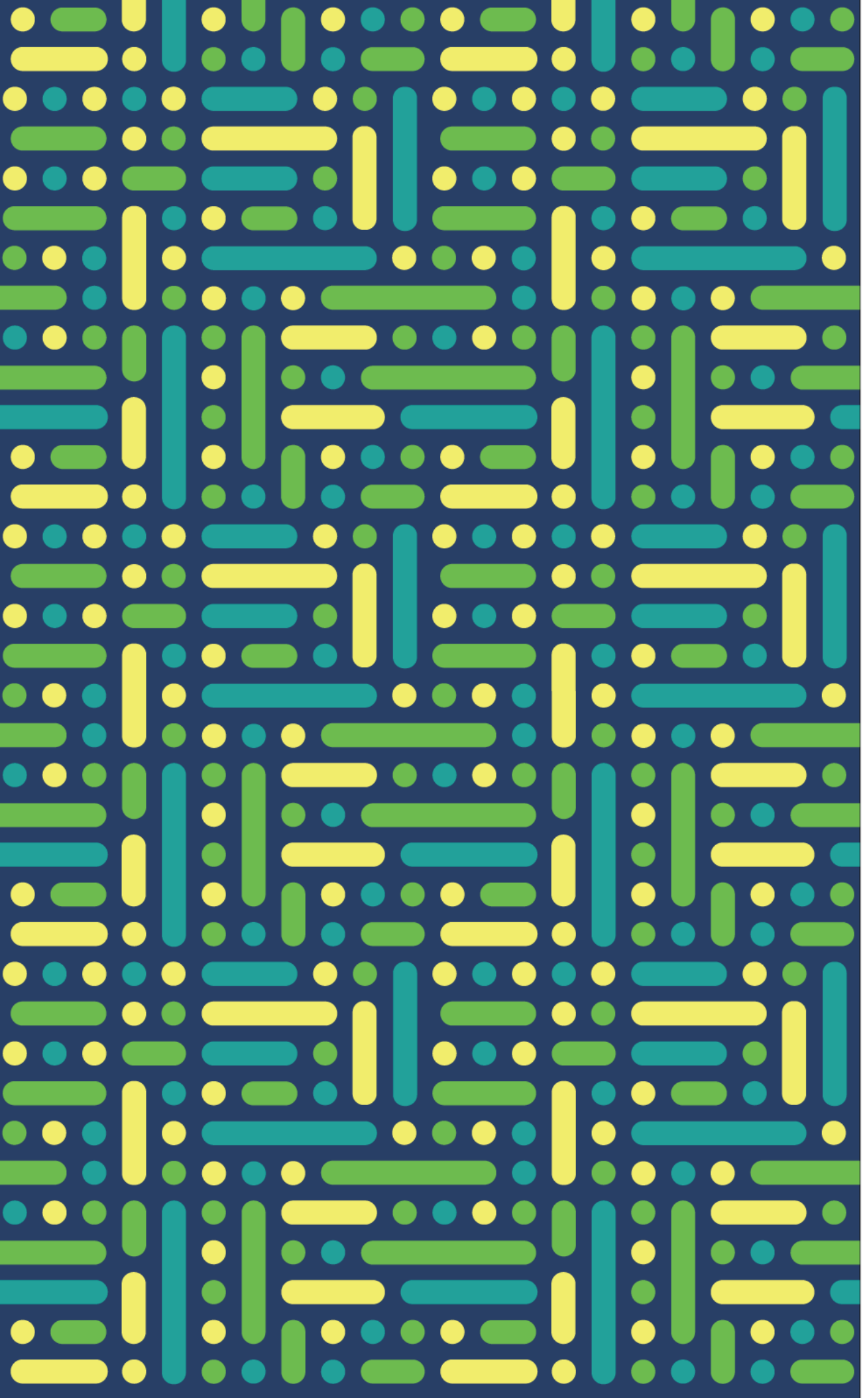
We also want to thank the 2021 Human Practices, Engineering, Safety and Security, Diversity and Inclusion, Responsible Conduct, and Sustainable Development Goals Committees for the countless hours they have worked to make iGEM even better this year. We have so many wonderful people who help out on our 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 2021 Giant 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've done for the iGEM students and hope you've enjoyed the experience.

We hope to see you back as a judge for 2022!

With sincere thanks,

The Judging Program Committee, Judging Corps Committee, and iGEM Headquarters



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