2017 GIANT JAMBOREE

JUDGING HANDBOOK

A GUIDE TO JUDGING AT THE GIANT JAMBOREE

Table of Contents

INTRODUCTION

Introduction from the Executive Judging Committee

Welcome Judges! Thank you in advance for your service to iGEM this 2017 season. No matter how deeply steeped you are in our traditions of judging, there is new evolution every year. This Judging Handbook serves to help train new judges and update veteran judges. By being a public document, it also serves teams by "lifting the veil" on what once appeared (unintentionally) to be a mysterious and secret process. All members of the iGEM community can see the Handbook, having access to the same information as the judges.

The Handbook has been updated from last year, including more recent examples of award-winning work from iGEM teams. Many iGEM judges have contributed, especially the numerous case studies that can help all judges better understand their task. If you are a new judge, we understand there is a lot to learn! Please do your best to go through this handbook.

There is much to learn about the different kinds of iGEM awards, and how they are decided. Be aware that some portions are more like a reference manual: not essential reading, but there for you if you need it. If you are a returning "veteran" judge, there are some changes and updates to be aware of—please make sure that you examine the material highlighted as "new" in the Handbook. This includes updates to medal requirements, which have been significantly modified.

Each medal level has been made more challenging to reach, though we have also sought to clarify the requirements language to reduce misunderstandings for both teams and judges. For reaching the Gold medal level, teams must meet two of the options provided—one of which is now about modeling. An important new addition this year is "What Happens When I Cast a Vote?" We recommend this short summary on page [#] as essential reading.

Two years ago we consolidated the roles of specialized iGEM judges into one unified judging panel. With iGEM's continued growth, we realized it was not sustainable to have large committees of judges for deciding single awards, such as Best Poster and Human Practices. We now ask each iGEM judge to serve as a "master generalist" in evaluating all aspects of a team's work, including each special prize the team is eligible for. But the individual areas of special expertise brought by each judge are still considered essential—we seek to take this into account when determining track assignments.

At the same time, we ask that judges consider how to strengthen their perspective in the areas where they are less advanced. This Handbook is intended to be a valuable resource for that effort. Discussions with other judges at the Giant Jamboree will continue to be vital toward that goal as well.

We recognize that iGEM asks a great deal from judges as well as from teams. Each year we ask how we can make the judging process easier to understand and perform. This year an important theme has been harmonization. We are working to make team requirements as clear as possible, and consolidated into easy-to-locate web pages. This work goes hand-in-hand with iGEM's substantial revision of their web pages this year.

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

Giving feedback to each team is an essential aspect of striving for that goal. You will have many opportunities to provide your insights to teams throughout the Jamboree—in your comments after their presentations, in your interactions at their posters, in your evaluation of the team using the judging rubric, and in the comments judges submit through their judging dashboard. Please do as much as you can to praise what is praiseworthy balanced with fair constructive criticism. The students have so much that they gain from your insights. Thank you again for being an iGEM judge.

With much appreciation,

The iGEM 2017 Executive Judging Committee
Peter Carr - Director of Judging
Beth Beason-Abmayr
Janie Brennan
Nils-Christian Lübke
Jessica Tang
Kim de Mora

How to begin your judging assignment

Teams are competing for 4 main prize categories in the iGEM competition:

- **Medals**
- **Track prize**
- **Special Prizes**
- **Grand prize**

When you begin your assignment, you will navigate to the online team judging form and rubric to evaluate teams based on these 4 prize categories. The mechanics of how to perform your judging assignment using our online system will be described later in the year, so we will not go into detail in this section.

When using the online judging form and rubric, the first thing you should do is evaluate the team against the medal criteria (see the "Medals" section of this document 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 criteria, but you feel they have not achieved enough to warrant the medal, you can choose not to award them for it. A similar philosophy should be used for all of the rubric aspects in iGEM.

Once you have determined which medal you have decided to award the team, you can move on to evaluating the rest of the rubric for the team. The "Project" section of the rubric 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.

After evaluating the "Project" section, any other open sections in the rubric will identify which awards the team is competing for. In most cases, the award will directly link to a page on the team wiki with information about what the team have achieved to warrant winning that award. This mechanism is intended to make the lives of judges much easier. *If a team has not used the designated wiki link for that award, you do not have to judge them for that prize*.

This measure is intended to encourage teams to be clear 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** on the iGEM website.

Finally, the highest ranking teams as determined by the "Project" section will become finalists and present during the award ceremony. The last act of being a judge at iGEM is to vote on which team will win the coveted BioBrick trophy. This is done as part of a meeting following the finalist presentations, during the award ceremony.

Points to consider during your evaluations

On Feedback

Teams care about getting feedback from judges. Many teams will win awards, but most will not, simply because we do not 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 sent to teams. Your written comments will be aggregated and displayed on the same page as scores.

We ask judges to provide two types of written feedback: positive feedback and constructive criticism. Written comments are important to teams, so please do write something for each of your teams, even if it is a single line on what you think of their project. We intend to release the feedback to teams within two weeks of the Jamboree. Please write feedback to teams and ensure your comments are entered no more than a week from the Jamboree, so we can give the information to teams.

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 the Responsible Conduct Committee

iGEM has a series of values that we take seriously. Integrity, good sportsmanship, respect, honest, celebration, cooperation, effort and excellence are some of the values that we place in high regard for all participants. iGEMers, 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** for more information including hypothetical case studies. If you think a case of misconduct requires investigation, please contact: **RCC@iGEM.org**.

On Attribution

We have made some important changes with regards to attribution in iGEM this year. Previously, attribution was evaluated in the Project, Wiki, Poster, and Presentation sections of the rubric. For 2016, we have reduced this to only the Project and Wiki sections.

Why the change? We spent a lot of time at HQ asking ourselves, “What we are really trying to evaluate with attribution?” There is a lot of confusion on this subject in iGEM and it was one of the most-asked questions at the judging table at previous Jamborees. We care about teams telling us what they did and where their ideas originated.

An easy trap to fall into is to think that the only iGEM projects of value are the ones with scienti c novelty. This assumption is not correct, as the rst team to make a project actually work and have an impact may not be the rst team to have the original idea. Because of this failure of clarity of language, we have removed all references to attribution from the rubric.

The two relevant aspects in the rubric are now:
Project - How much of the work did the team do themselves and how much was done by others?
Wiki - How well does the team describe what they did and what was done by others?

Consider the following example: A team presents amazing microscope images in their presentation and on their wiki. Did they acquire the images on the microscope themselves? Did a technician in a core facility acquire the images and give them to the team? Or did the technician train the students on how to use the microscope and guide them through acquiring the great images? Whatever the case may be, judges want to see the team adequately describe what they have done on the attributions page on their wiki.

We also care about how well the team describes what they did vs. what was done by others. The perception of only valuing scienti c novelty is not effective in helping judges get the information they need, and this example is one more area where iGEM goes above and beyond convention. We feel that thinking about what the team did in this way is the most honest and respectful approach.

On Engineering

Rob Carlson published "Biology is Technology: the promise, peril, and new business of engineering life” in 2010, reporting on approximately the rst decade of synthetic biology.

The title of the book itself highlights the engineering nature of this eld and how important applications are to take biological engineering out of the lab and into the world. While we would like to re-print a lot of what Rob has published, we have selected 6 key quotes describing how synthetic biology is developing as an engineering discipline and catching up to aeronautical and electrical engineering:

Page 4, Engineering Organisms Is Difficult, for Now

The initial phase of biological engineering, covering the last thirty years or so, coincided with efforts to describe the fundamentals of molecular biology. In that time we moved from discovering the number of genes in the human genome to building automated machines that read entire microbial genomes during a lunch break. Science has accumulated enough knowledge to support basic genetic changes to microbes and plants; those changes enable a wide range of rst-generation products.

Page 6, What Is Biological Engineering?

Aeronautical engineering, in particular, serves as an excellent metaphor when considering the project of building novel biological systems. Successful aeronautical engineers do not attempt to build aircraft with the complexity of a hawk, a hummingbird, or even a moth; they succeed by rst reducing complexity to eliminate all the mechanisms they are unable to understand and reproduce. In comparison, even the simplest cell contains far more knobs, bells, and whistles than we can presently understand. No biological engineer will succeed in building a system de novo until most of that complexity is stripped away, leaving only the barest essentials.

Page 9, Every Piece Has Its Purpose

Mature engineering elds rely on computer-aided design tools—software packages like SolidWorks for mechanical engineering and Spice or Verilog for circuit simulation—that are based upon predictive models. These predictive models are constructed using a quantitative understanding of how parts of cars and airplanes behave when assembled in the real world. Unlike the vast majority of modi ed biological systems, for which there are no design tools, the behavior of a nished engine or integrated circuit can be predicted from the behavior of a model, which today is universally determined using computer simulation.

Page 21, Learning to fly (or Yeast, Geese, and 747s)

Most models and experimental predictions in biology are natural language stories. Models of protein function today often have the structure of "Protein X binds to Protein Y" or "Protein X recognizes and cleaves a certain DNA sequence." For the most part, there aren't any numbers included. These sorts of models lack quantitative predictive power, whereas engineering generally requires a framework of quantitative models based on quantitative experiments.

Quantitative experiments have certainly been done in biology, and models constructed to describe the results, but they have generally been aimed at describing the behavior of populations rather than individuals.

Page 81, The International Genetically Engineered Machines Competition

As I will describe in more detail over the course of this chapter, the success of the "Eau d'E. coli" project is in no small part due to the application of standard engineering principles to biology. Like modern airplane and computer design, the resulting circuit was assembled not with the knowledge of many molecular details but with abstraction of those details through the use of parts with prede ned functions providing for substantial simpli cation in the process of design and construction. Only when necessary did the team delve into the details, such as when they developed new parts according to the standards set for iGEM. The synthetic circuit that resulted from the Eau d'E. coli project contained a remarkable twenty-four components.

The Imperial College London Engineering Design Cycle

While Rob's book describes the direction the eld is headed, Imperial College London have worked on the application of engineering principles to their iGEM projects for the last 10 years.

As previously mentioned, the rst team to have an idea may not be the rst team to make that idea work. This statement may sound sacrilegious to a scientist who relies on novelty for everything from grant money to tenure, but this is not the case in most engineering elds. Engineering proceeds in a cycle, is an iterative process, and is usually not based on new theories, but more established techniques that can work reliably in a variety of environments.

Page 84, Bringing Complexity Engineering to Biology

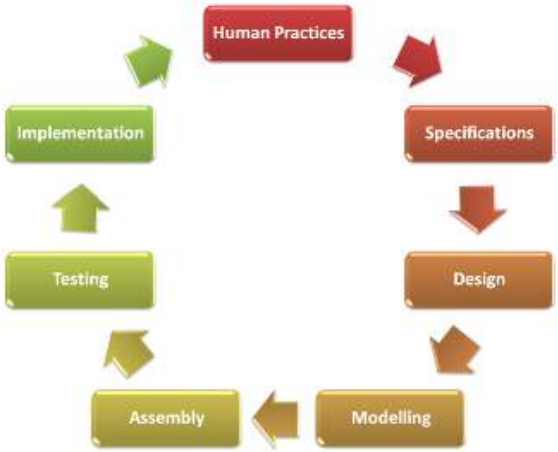
The cumulative effect of standardization, decoupling, and abstraction has been to take the "electrical" out of electrical engineering. Tom Knight, a senior scientist at MIT's Computer Science and Arti cial Intelligence Laboratory and an early participant in designing hardware and software for ARPANet, sees his eld now as "complexity engineering": "In most respects the association of electrical engineering with electromagnetism is now almost incidental. We have become complexity engineers, rather than experts in [electricity and magnetism].

Few other disciplines design, build, and debug systems as complex as a modern computer system, either from the perspective of hardware, with billions of components, or with software, with millions of lines of code."

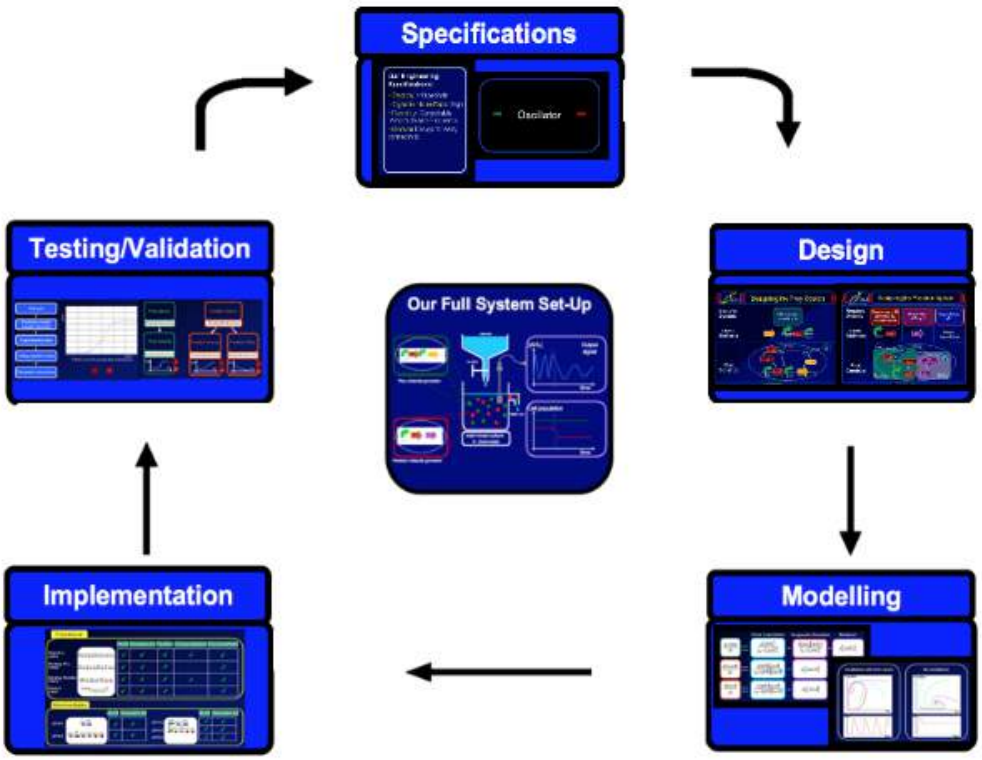
Engineering design cycle from ICL 2006. Updated design cycle to include human practices from ICL 2011.

The engineering design cycle has 5-7 stages, depending on the context of the work:

1.- Specification
2.- Design
3.- Modeling
4.- Implementation
5.- Testing/Validation
6.- Return to 1.



Imperial College London have included the engineering design cycle in their projects since presenting it during the 2006 iGEM competition. In 2011, they updated this cycle to include Human Practices, a rst within the iGEM community. This framework is a great way for teams to think about how to progress their projects over the summer.



What Happens When I Cast a Vote?

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

In the online rubric system, each judge casts votes pertaining to medal achievement and various project-related categories. Each team is initially 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 rubric category, the votes from that panel of six judges is then used to determine award eligibility and winners. *Thus, it is very important to match your vote to the rubric language 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, Wiki, and Poster categories

Track Prizes:
Highest score from a weighted average of the Project, Presentation, Wiki, and Poster 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., Undergrad and Overgrad)

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 "quality". 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 rubric 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!

MEDALS

Medals

Summary:
- Teams earn medals by meeting specific criteria. There are separate medal requirements for Standard Tracks (includes High School teams) and Special Tracks.
- 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 static wiki page links in the Judging Form. 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 they have achieved the requirements and/or criteria.

Finalists demonstrate the very best work in a given year in the iGEM competition, but all teams are competing for medals. The number of medals is not limited and teams are only competing with themselves to meet the criteria. Teams can be awarded no medal, bronze, silver, or gold. For a bronze medal, teams must meet all 4 criteria. For a silver medal, teams must meet the 3 medal criteria in addition to the bronze medal criteria. For a gold medal however, teams must meet at least 2 of the 4 available criteria in addition to all of the bronze and silver medal criteria.

Static Links and Pages for Awards NEW

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.

If a team wants to be evaluated for an award/medal, they will need to document their achievements related to this award/medal on specific pages. For example, if a team wishes to achieve a bronze medal, they need to complete the attributions page on: **http://2017.igem.org/Team:Example2/Attributions**.

This bronze medal criterion is highlighted in the team example menu in the image to the right. It also has a star next to the name, indicating the page is tied to an award.

Below you will find a list of all of the pages for specific awards and medal criteria in your wiki template.

The judges are directed to these pages from static links within the judging form. If a team does not provide sufficient documentation to convince you they have achieved an award/medal criterion in their static link, *you can choose not to evaluate them for the prize or medal criterion in question.*

While teams can create additional pages and link off from their pages for awards, they should provide sufficient information to allow judges to make a decision.

Why did we make this change?
In the past, teams were required to enter their own page links into the judging form to be evaluated for some awards. Sometimes these links did not work. For example, some teams used web design packages that created dynamic links, and the judging system could not identify the correct pages.

Since specific pages on the wiki can be hard to find, we created these pages for awards with static links to help the judges find the information they need to evaluate specific awards. When a team creates a project wiki, they are not limited to using only these evaluated pages. However, judges may choose not to examine content on additional pages.

One way to think about this idea is in terms of publication structure. Including all the data involved in a publication would make it much harder to communicate the main idea. Teams should put all the information needed to convince judges on the award page, 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 below. 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 below, as well. All content (except part pages on the Registry) should be contained in the official team name space.
For example:
http://2017.igem.org/Team:Example2.

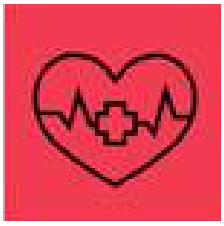
When a team is competing for an award, note that it is not sufficient for them to simply fulfill the award criteria. You should be convinced that a team has satisfactorily fulfilled the criteria. If you are not convinced after reading documentation from the team (on the wiki and on the Registry), you may choose to not award the prize.

Standard Tracks and Special Tracks

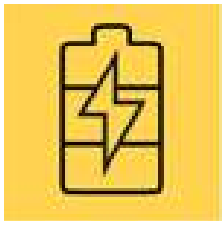
There are only two sets of medal criteria, one for standard tracks and the other for special tracks. The **2017 medals page** lists the criteria (also given below). Please note the additional notes included that teams must access by clicking on the "+" sign. In short, the main difference between the two sets of criteria is based on the use of BioBricks.

For teams in the standard tracks, BioBricks are central to the projects. Teams in the special tracks do not necessarily need BioBricks for their projects; additionally, these teams can present their work in exhibition spaces at the Jamboree. (Special tracks are described in detail later in the handbook).

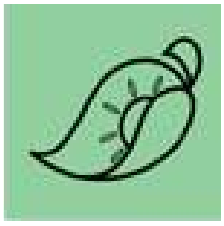
Standard Tracks



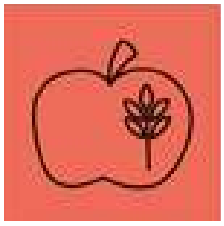
Diagnostics



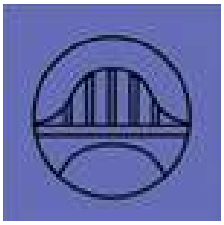
Energy



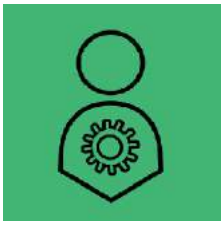
Environment



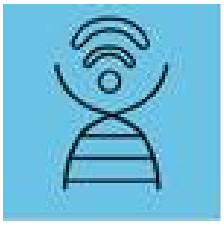
Food and Nutrition



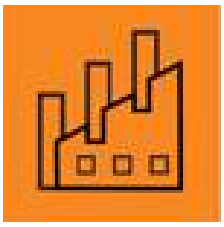
Foundational Advance



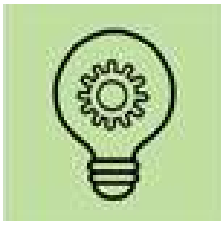
High School



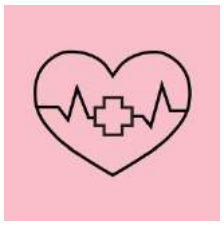
Information Processing



Manufacturing

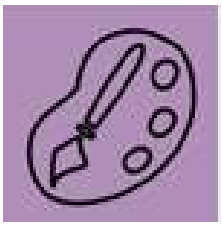


New Application

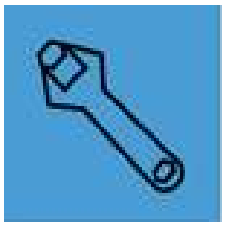


Therapeutics

Special Tracks

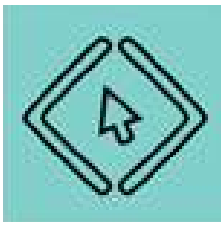


Art and Design



Hardware

Measurement



Software

All criteria must be met

Standard Tracks	*Special Tracks*

1.- Register and attend

Register for iGEM, have a great summer, and attend the Giant Jamboree.

2.- Deliverables

Standard Tracks	Special Tracks
Meet all deliverables on the **Competition Deliverables** page (section 4).	Meet all deliverables on the **Competition Deliverables** page (section 4), except those that specifically mention parts.

3.- Attribution

Create a page on your team wiki with clear attribution of each aspect of your project. This page must clearly designate work done by the students and distinguish it from work done by others, including host labs, advisors, instructors, sponsors, professional website designers, artists, and commercial services.

Judges often wonder what a team has accomplished themselves. This page is your opportunity to explain what parts of your project you did and what was done by technicians, advisers, etc. This requirement is not about literature references - these can and should be displayed throughout your wiki! Please also see the **Purdue Online Writing Lab** for more information on how to avoid accidental plagiarism.

4.- Characterization / Contribution NEW

Standard Tracks	Special Tracks
Participate in the **Interlab Measurement Study** and/or improve the characterization of an existing BioBrick Part or Device and enter this information on that part's Main Page in the Registry. The part that you are characterizing must NOT be from a 2017 part number range. Please see the **iGEM Registry Contribution** page and the **interlab measurement study** page for more information. If characterization involves fluorescence, values must be reported in iGEM standard units (uM/OD or MEF).	Participate in the **Interlab Measurement Study** and/or document at least one new substantial contribution to the iGEM community that showcases a project related to BioBricks. This contribution should be central to your project and equivalent in difficulty to making and submitting a BioBrick part. Please see the interlab measurement study.

All criteria must be met

Standard Tracks | *Special Tracks*

1.- Validated Part / Validated Contribution

Convince the judges that at least one new BioBrick Part of your own design that is central to your project works as expected. Document the experimental characterization of this part on the Main Page of that Part's Registry entry. Submit a sample of this new part to the iGEM Parts Registry (following Registry submission guidelines). This working part must be different from the part documented in gold #2.

Don't forget to please carry over the links from Deliverables for Sample Submission from 2016: Teams are asked to submit samples of their new Parts to the Registry to help make the Registry better each year. Teams must follow our DNA Submission Guidelines to qualify for medals. Teams need to mail their samples by the Sample Submission Deadline and provide a tracking number as proof that they sent their DNA on time. Failure to follow our guidelines may result in a rejected shipment or sample, which may disqualify your team from winning medals and awards.)

Convince the judges that something you created (art & design, hardware, software, etc.) performs its intended function. Provide thorough documentation of this validation on your team wiki.

2.- Collaboration

Convince the judges you have significantly worked with any other registered iGEM team in a meaningful way. For example, mentor a team, characterize a part, troubleshoot a project, model/simulate a system or validate a software/hardware solution to a synbio problem, or be the recipient of any of these activities.

You should convince the judges that the nature of your interaction is bi-directional; they may look at the other team's wiki to see what they say about your interaction. Simply filling out a survey for a team is not enough to demonstrate a significant interaction).

3.- Human Practices

Convince the judges you have thought carefully and creatively about whether your work is safe, responsible and good for the world. You could accomplish this through engaging with your local, national and/or international communities or other approaches. Please note that standard surveys will not fulfill this criteria.

See the **Human Practices Hub** for more information and examples of previous teams' exemplary work.

At least two (2) criteria must be met

Standard Tracks *Special Tracks*

1.- Integrated Human Practices

Expand on your silver medal activity by demonstrating how you have integrated the investigated issues into the design and/or execution of your project.

See the **Human Practices Hub** for information and examples of previous teams' comprehensive and innovative activities.)

2.- Improve a previous part or project

Improve the function of an existing BioBrick Part. The original part must NOT be from your 2017 part number range. If you change the original part sequence, you must submit a new part. In addition, both the new and original part pages must reference each other.

If you do not change the part sequence, your improvements must be documented on the original part's Main Page in the Registry.)

Improve the function of an existing iGEM project (that your current team did not originally create) and display your achievement on your wiki.

3.- Model your project NEW

Convince the judges that your project's design and/or implementation is based on insight you have gained from modeling. Thoroughly document your model's contribution to your project on your team's wiki, including assumptions, relevant data, and model results.

Judges are looking for modeling that matters. You should be able to explain your model to someone with a non-mathematical background. Simply displaying pages of differential equations does not constitute good modeling. See these examples: **Manchester 2016**, **Czech Republic 2015**, **ETH Zurich 2015**).

4.- Demonstrate your work NEW

Convince the judges that your project works.
Projects have to work under under realistic conditions. Your project must comply with all rules and regulations approved by the **iGEM Safety Committee**. Your project can derive from or make functional a previous iGEM project by your team or by another team. For multi-component projects, the judges may consider the function of individual components.

Changes and updates to medal criteria

Bronze Medal Criterion 4

Participate in the **Interlab Measurement Study** *and/or improve the characterization of an existing BioBrick Part or Device and enter this information on that part's Main Page in the Registry. The part that you are characterizing must NOT be from a 2017 part number range.*

To achieve this criterion, teams can demonstrate that they have participated in the interlab study by providing data and/or they can improve the characterization of an existing BioBrick. Teams cannot fulfil this criteria using a BioBrick from their part range. Characterization could include measuring some property of an existing part, improving the references, showing the resolved protein structure, etc. This criteria is different to Gold #2, where teams must demonstrate that they have improved the function an existing part in the Registry.

Silver Medal Criterion 2 NEW

Convince the judges you have helped any registered iGEM team from high school, a different track, another university, or another institution in a significant way.

Collaboration is now a silver medal requirement whereas in previous years it was an option for a gold medal. We expect teams to demonstrate two-way collaborations. Teams should showcase what they did on each other's wikis in order to demonstrate actually working together. There are many things that teams can do to collaborate, but the keys here are that the team(s) they collaborate with also showcase the efforts, and they collaboration is not trivial in nature. If a team simply filled out survey, that should not count as a true collaboration.

Silver Medal Criterion 3 NEW
Human Practices

Convince the judges you have thought carefully and creatively about whether your work is safe, responsible and good for the world. You could accomplish this through engaging with your local, national and/or international communities or other approaches. Please note that standard surveys will not fulfill this criteria.

To qualify for a silver medal, teams must demonstrate how they have identified and investigated one or more Human Practices issues in the context of their project.

The language for this criteria this year has been changed this year, asking teams to demonstrate to the judges that they have thought carefully and creatively about whether their work is safe, responsible, and good for the world. They could, for example, consider the regulatory, economic, ethical, social, legal, philosophical, ecological, security or other societal aspects of their projects. **We want to see thoughtful and inventive approaches to examining these complex issues in ways that are relevant to teams' work**. One way (but not the only way) teams may accomplish their examination is by engaging with stakeholders in their local, national and/or international communities. We also want to recognize other creative approaches to exploring these issues. If teams choose to use surveys, we expect them to follow best practices for conducting a scientific and legitimate surveys, and have provided resources and information on the **HP Hub**. Many good examples of Human Practices work and additional information can also be found on the hub.

Gold Medal Criterion 1 NEW
Human Practices

Expand on your silver medal activity by demonstrating how you have integrated the investigated issues into the design and/or execution of your project.
.

To qualify for a **gold medal**, teams must complete two of the four requirements listed on the **official medal criteria page**. To qualify for gold using Human Practices work, teams must expand on their silver medal activities by demonstrating how the investigation of their HP issues has been integrated into the design and/or execution of their project. Just talking about their project with people outside their labs DOES NOT meet this requirement. Teams should show how their conversations with people outside the lab, and/or other activities to they have pursued to investigate these issues, have influenced their projects. **We want to see how iGEM projects (lab design, parts selection/development, overall application, etc.) have evolved based on team's Human Practices work.** We have encouraged teams to consider the design/build/test/learn cycle of engineering.

Gold Medal Criterion 3 NEW

Model your project.

Modeling has been a part of iGEM for many years, but this is the first time it has been included as an optional medal criterion. Teams must show that they have modeled part of their project and that the insight derived from that component was used to determine the direction of their project.

Gold Medal Criterion 4 NEW

Demonstrate your work.

This criterion can be fulfilled in a number of way, depending on the type of project. The judging committee has left this criterion open to the discretion of the judges. There is no specific thing we are looking for, just that the team has succeeded in making a part of or their whole project work in some way that they can demonstrate.

Evaluated Page Links in Team Judging Forms

Below are standard links to the team "Example2" template pages for the medal requirements and the special prizes. For team pages, please replace "Example2" with the team name to find the page on the wiki, or navigate to that page using the menu in the team namespace. Standard track and Special track teams must complete these wiki pages to qualify to be evaluated for a medal, special prize or track award.

Bronze

All criteria must be met:

Bronze #1:
No special page required.

Bronze #2 (Deliverables):
Complete all deliverables in section 3 of Requirements page: **http://2017.igem.org/Competition/Deliverables**. No special wiki page required.

Bronze #3 (Attributions):
http://2017.igem.org/Team:Example2/Attributions

Bronze #4 (Contribution / Interlab):
Contribution:
http://2017.igem.org/Team:Example2/Contribution_
and/or
Interlab:
http://2017.igem.org/Team:Example2/InterLab

Silver

All criteria must be met:

Silver #1 (Part data):
Part number in your part number range is required when filling out the judging form. Data must be on the Part page on the Registry. You must also submit this part to the Registry to achieve this medal criterion. This part must be different from the part documented in gold #2.

Silver #2 (Collaboration):
http://2017.igem.org/Team:Example2/Collaborations

Silver #3 (Human Practices Silver):
http://2017.igem.org/Team:Example2/HP/Silver

Gold

At least **two (2)** criteria must be met:

Gold #1 (Integrated Human Practices): http://2017.igem.org/Team:Example2/HP/Gold_Integrated

Gold #2 (Improving a previous part or iGEM project):
This part must be different from the part documented in silver #2.
http://2017.igem.org/Team:Example2/Improve.

Gold #3 (Model your project):
http://2017.igem.org/Team:Example2/Model

Gold #4 (Demonstrate your work):
Convince the judges that your project works.
http://2017.igem.org/Team:Example2/Demonstrate

EXCELLENCE IN IGEM

Excellence in iGEM: Finalist Case Studies

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 poster, a presentation at the Jamboree, and, depending on the track, some sort of deliverable to be used by the community (e.g., DNA parts, software, an art installation, 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 about education; projects should be motivated, researched, and carried out primarily by students. Effective use of available resources is important, but careful attention should be paid to attribution of each part of the project.
These facets of success are reflected in the "Project" section of the rubric, which is the main determinant for choosing finalists:

1.- How impressive is this project?
2.- How creative is the team's project?
3.- Did the project work?
4.- How much did the team accomplish?
5.- Is the project likely to have an impact?
6.- How well are engineering principles used?
7.- How thoughtful and thorough was the team's consideration of human practices?
8.- How much of the work did the team do themselves and how much was done by others?
9.- Did the team design a project based on synthetic biology and standard parts?
10.- Are the parts' functions and behaviors well-documented in the Registry?

The first eight aspects are the key iGEM values that apply to all teams, irrespective of track. The final two aspects are distinct for standard (parts-based) tracks and special (non-parts-based) tracks. The aspects shown above are for standard tracks. Due to significant differences in project design and execution, it is important to note that special track teams are not eligible to be finalists or to win the Grand Prize. For more information on special tracks and how to judge them, see the relevant sections later in the Handbook, as well as the chapter on medal requirements.

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 projects:

Imperial College 2016

Czech Republic 2015

Heidelberg 2014

UC Davis 2014

Imperial College London 2016

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.
They wanted to design a genetic circuit that allows ratiometric control of populations in co-culture.

Three components were used:

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

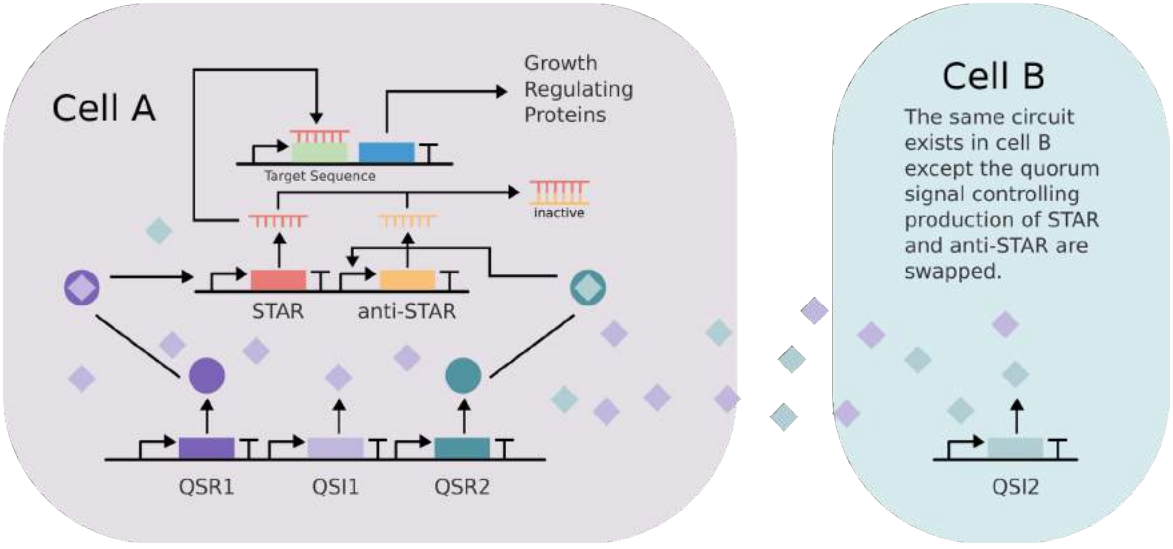
2.- The comparator module that links quorum sensing to RNA logic so that the population can compare their own population to the other population cell-line

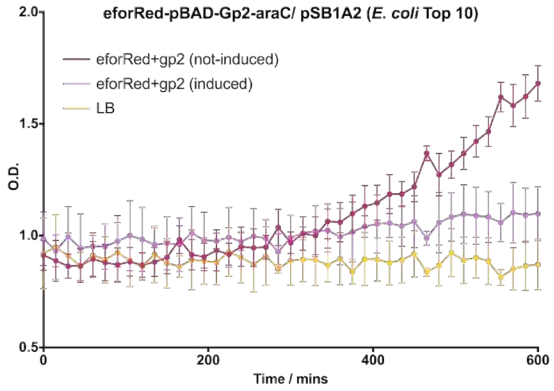
3.- A growth regulation module that allows the cell line to respond to the signal from the comparator's module to regulate each other's population growths

These three components make up Genetically Engineered Artificial Ratio (G.E.A.R.) system as shown in the figure at the bottom of the 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 and 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 below 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

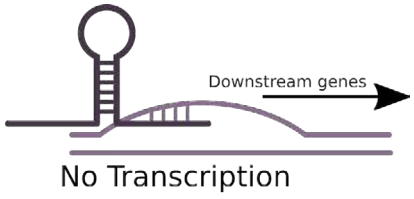


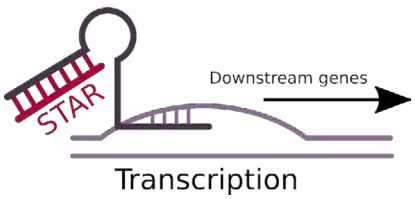


In judging this team's accomplishments, in relation to the scoring rubrics:

This project was i**mpressive** (**aspect 1**) especially in their design using **engineering principles** (**aspect 6**) of the co-culture experiments, the amount of work done in characterizing their components and also incorporating mathematical modeling of each module of the G.E.A.R. system. They have shown that they were able to accomplish many of their set tasks (**aspects 3, 4**).

There are many aspects that were **creative (aspect 2)** 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**.





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

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 (**aspects 9, 10**). They also designed a computer software tool called **Advanced Logging Interface for Culture Experiments (A.L.I.C.E.)** 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 (**aspect 5**).

The judges were very impressed by the h**uman 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** (**aspect 7)**. The team clearly stated in their wiki the attributions and their collaborations (work done by **themselves or others, aspect 8**).

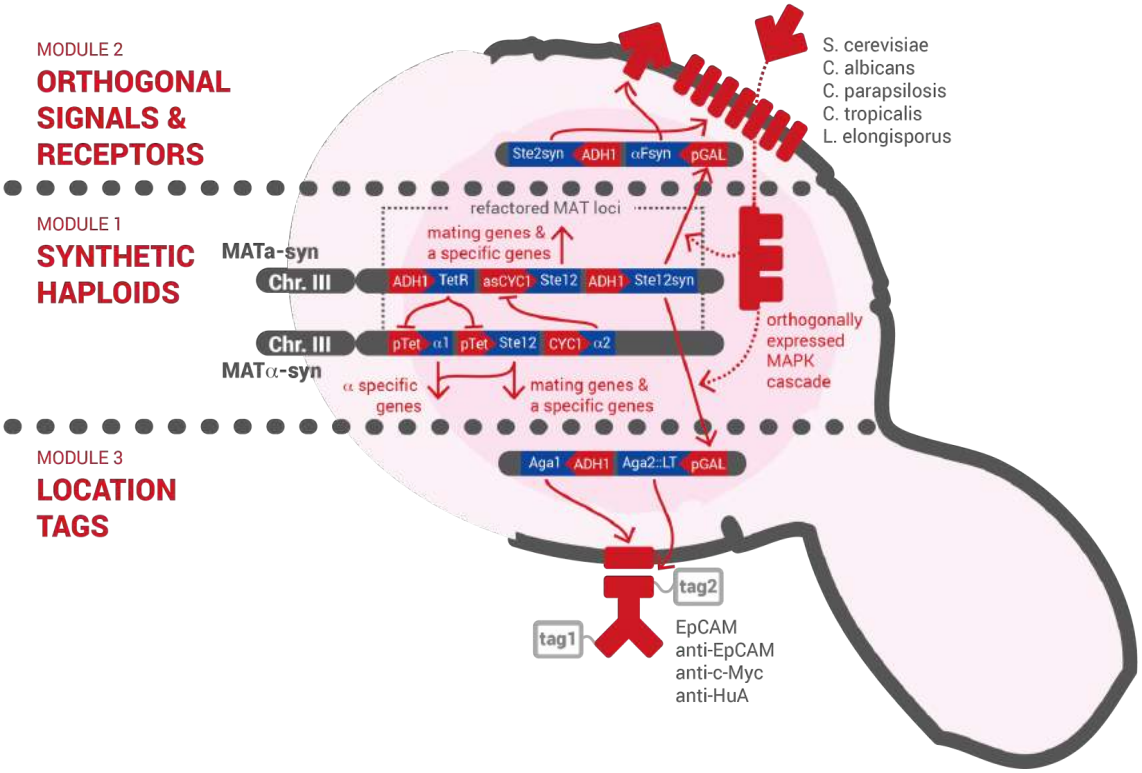
Apart from the impressive data from the wet and dry lab experiments, the team produced a wiki and poster that were both fun and eye-catching with high quality graphics, resulting in their also winning the Best Wiki and Best Poster special prizes.

Czech Republic 2015

The project of Czech Republic 2015 dealt with the development of a cheap and easy-to-use test to detect the presence of cancer cells that left the primary tumor to migrate into other organs (so called Circulating Tumor Cells, CTCs) in a sample of peripheral blood . Being able to detect CTCs early enough (before they have the chance to form metastases in other organs) would potentially save many lives. The beauty of the project lies in its modularity and in the novelty of the approach. It impressed the judges and was awarded with 1st Runner Up, Undergrad, at the Giant Jamboree in 2015.

The idea at the core of the project was to engineer yeast cells to: a) expose on their surface a single-chain variable fragment (scFv) antibody for the recognition of a specific antigen in the extracellular medium and b) react by forming clumps visible to the naked eye. The team thought of exploiting the very well studied yeast pheromone response pathway; haploid yeast cells use this MAPK signaling cascade to detect the presence of cells of the opposite mating type – announced by their pheromone – and to respond by arresting the cell cycle, expressing mating-specific genes, and growing a mating protuberance in the direction of the mating partner. The name of the project was IOD band. IOD stands for Input Output Diploids. Yeast diploids arise from natural mating between two haploid cells, a process that the team called “clone-free” assembly.

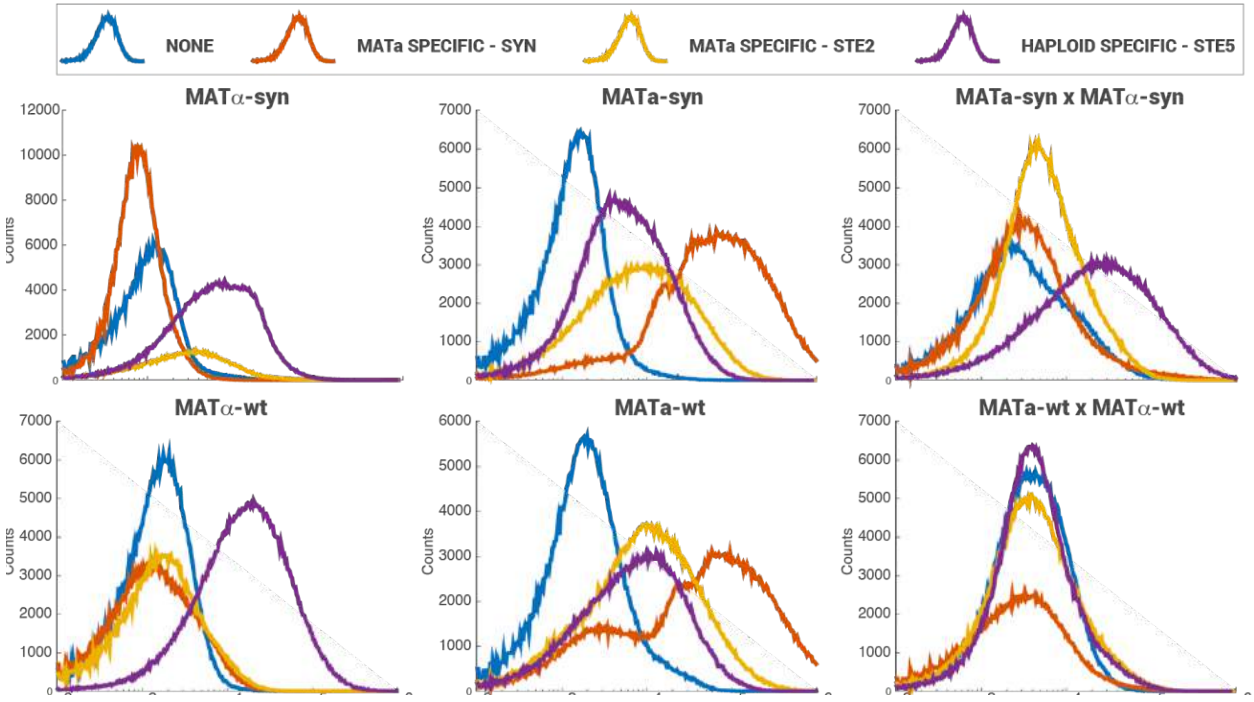
The following graphic from the team’s wiki shows the main concepts of the project, including its modularity:



A very interesting engineering part of the project consisted in finding ways to keep the mating pathway turned 'on' in diploid cells while not allowing synthetic diploids to undergo further mating. The team's solution was two-fold: 1. They eliminated the natural transcription factor a1, which plays no role in haploid cells but represses expression of mating-specific genes. a1 was replaced by the tetracycline-dependent transcriptional repressor TetR; 2. They substituted the endogenous promoter of the Ste12 transcription factor (that activates mating genes) with a synthetic a-specific promoter which is repressed in diploids. Since Ste12 is essential for mating, it could not be eliminated in haploids as it was done with a1. Thus, a good solution the team found was to repress it only in diploids.

Moreover, they used a synthetic Ste12 protein obtained from another group, which is a hybrid between GAL4 and Ste12. This synthetic transcription factor binds to the GAL4 operator site, but is active only in presence of pheromone (which releases Dig1 and Dig2 from the activation domain of Ste12).

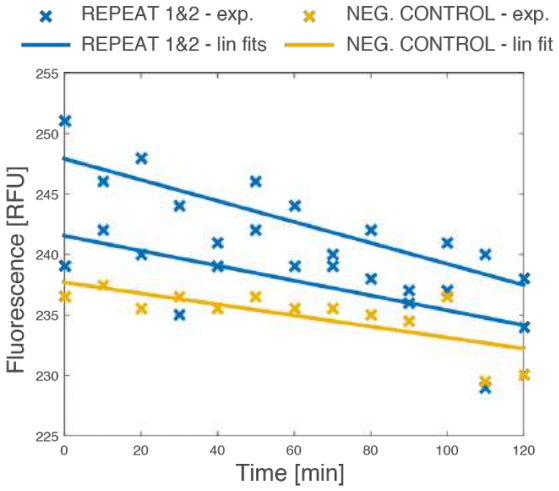
To test the functionality of their engineered haploid and diploid strains, the team conducted a series of experiments. First they checked the ability of the synthetic haploids to mate. Then they checked expression of a GFP reporter gene cloned under various promoters that were active either in haploid (a or alpha) or diploid cells.
Their flow cytometry comparison of the wild type and the synthetic strain support the idea that the strains behave as expected:



An important step was to prove that scFv antibodies exposed to the surface of the IODs were able to detect the presence of the antigen and form visible clumps. As a proof-of-principle, the team used well-known (non-cancer) proteins and scFv antibodies: biotin, EpCAM, c-Myc, and HuA. The latter was especially selected to carry out a first test with blood that contains this protein (human Antigen A). The technique to express scFvs on the yeast surface was already published and the team obtained the plasmids to perform yeast display from another laboratory. They could show that the selected proteins were exposed on the surface of their yeast strain by immunofluorescence.

They also showed that blood cells were retained on the yeast strain exposing the scFv antibody against human Antigen A. Finally, they mixed two yeast strains, one displaying anti-EpCAM scFv and another displaying EpCAM itself. The first strain produced wild-type pheromone after induction with copper sulfate. The second carried a reporter GFP gene that was induced by the pheromone produced by the other strain.

As the following picture shows, there was some minor GFP production when the two strains were mixed:



A big merit of the Czech Republic team was to develop a software environment called **CeCe** for modeling cell-cell interactions all the while simulating stochastic chemical reactions in the individual cells. In this simulated environment, cells enter and exit a 2D world through predefined channels of arbitrary shape. Stochastic reactions characterize each cell and they are executed when the cell is in the 2D world. Cells also interact with each other.

This project **impressed** the judges (**aspect 1**), because it is well thought-out, modular, and its various parts are very harmonious. The project has several nice **novel** ideas (**aspect 2**) that were absent from iGEM (for instance, an a-specific tunable promoter).

The team provides evidence that parts of their project **worked** (**aspect 3**) and used several techniques including microfluidics and mathematical modeling/ simulations. Therefore, they **accomplished** some important steps (**aspect 4**) towards this visionary idea of having a cheap and easy-to-use strip test for detecting CTCs.

Throughout their entire project, the team used concepts of engineering (**aspect 6**) and contributed several BioBricks to the Registry. Moreover, their simulation software is likely to have an **impact** (**aspect 5**) even outside of iGEM because other scientists in the community might want to use it.

In addition, among other activities such as a survey on GMOs, the team met with engineers and medical doctors to discuss with them their project and managed to attract engineers to synthetic biology (**aspect 7**). Finally, their presentation was extremely nice and well organized, and their graphics were professional and appealing, which of course always helps impress the judges!

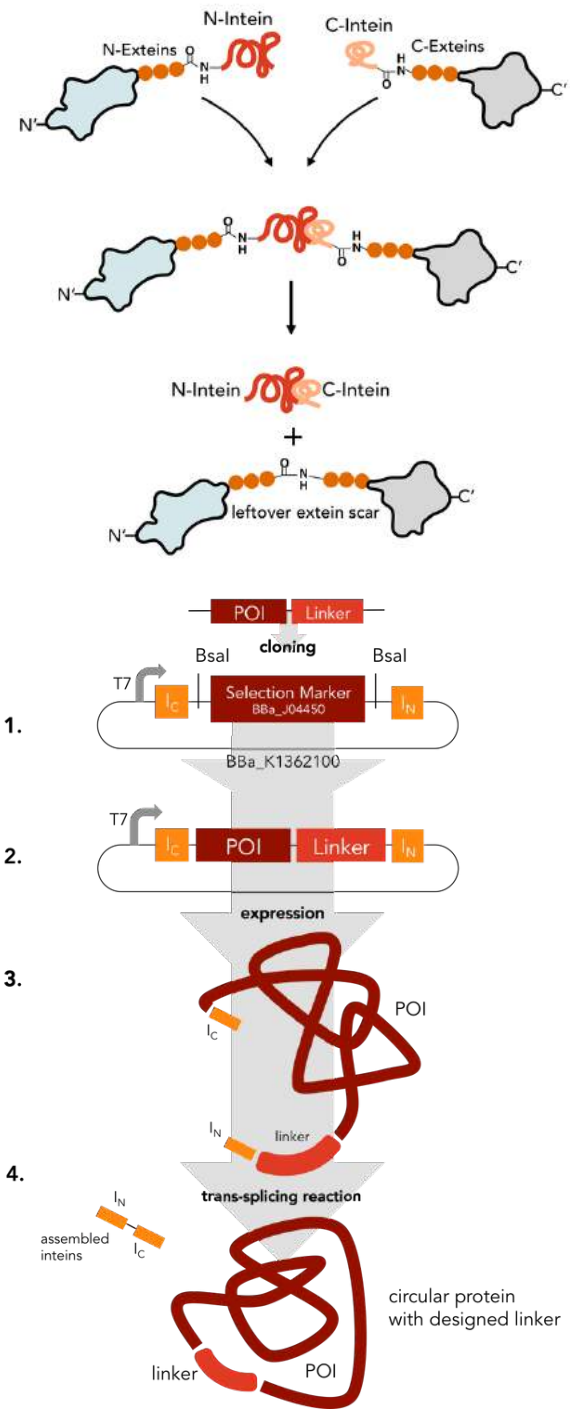
Heidelberg 2014

Heidelberg was the Grand Prize Winner in the Undergraduate section at the 2014 Giant Jamboree. For their project, Heidelberg chose to develop synthetic biology approaches for circularizing proteins, aiming to make those proteins more heat- and pH-stable and resistant to exopeptidases. As proofs of principle, they offer data on the heat stability of three enzymes that were never circularized before: lysozyme, the xylanase enzyme from B. subtilis (chosen for its relevance to industry, and for its potential high-temperature applications), and the DNA methyltransferase DNMT1. This last enzyme was selected with the idea to create a PCR 2.0, i.e. a PCR in which the methylation pattern would be preserved.

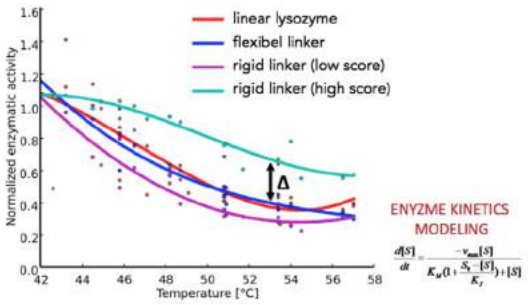
To circularize proteins in vivo, the team decided to use **inteins**, which mediate post-translational protein splicing. Inteins have been used by some iGEM teams before, but never for circularizing proteins. On their wiki, they show the general mechanism (left) along with the team's circularization method for a protein of interest (POI) (right).

Since for some proteins the termini might be too far apart to be connected with just the few residues needed for efficient intein splicing (the exteins), the team thought of giving to the users of their circularization construct the possibility to introduce a linker. In the literature, only flexible linkers have been used to connect relatively close termini. The team reasoned that rigid linkers might exert stronger stabilizing effects than flexible ones, and to this aim developed a software tool, CRAUT, to design the most appropriate rigid linker given the three-dimensional structure of the protein of interest.

They made their **software** - **available to the community with appropriate documentation** []. The software predictions were tested using lysozyme as model protein - they performed a huge number of assays to find the right conditions for the linkers screen!



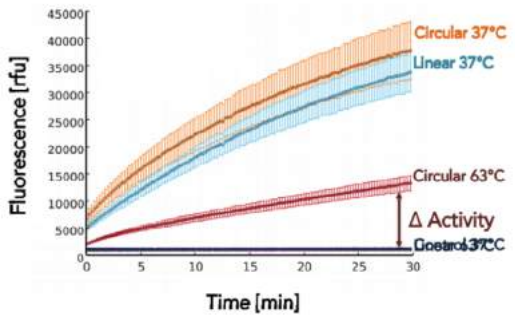
The images that follow are from their final presentation at the Jamboree:



The lysozyme circularized with a rigid linker had better heat stability than the linear enzyme or the variant circularized with a flexible linker.

Likewise, their circularized xylanase maintained appreciable activity at 63C compared to the linear version, which had practically no activity.

Finally, the heat stability of DNMT1 was improved by circularizing it:



Since the computations done by the CRAUT software are expensive (they are done at the level of the 3D protein structure), the team decided to develop the iGEM@home platform, that is based on the Berkeley Open Infrastructure for Network Computing (BOINC). This is the first time that an iGEM team introduced the concept of distributed computing to the iGEM community. iGEM@home was also nicely used by the team for their **human practices** (**aspect 7**) , reaching out to a wider community of non scientists with the concept of synthetic biology (Given current criteria, this would likely fall within the Education and Public Engagement category.)

Finally, even if the focus of the project was on circular proteins, Heidelberg also created a **toolbox** to use inteins for other post-translational modifications. The toolbox consists of BioBricks which have been submitted to the registry and of an online help to guide the user in the process of designing the appropriate construct.

In judging Heidelberg 2014, the team's accomplishments can be directly related to the rubric aspects. The project is **impressive (aspect 1**): the team produced a huge amount of novel data, created three different softwares (CRAUT, iGEM@ home and a notebook displaying software called **MidnightDoc**, and delivered both BioBricks and software tools that can be used by others.

For example, one judge commented: "Really great to see clean development of tools that make research easier for others: CRAUT, iGEM@home, thermostable DNMT1". The project is really novel (**aspect 2**) (circular proteins were never worked on before, the possibility to make a methylation-preserving PCR was also never presented, an entire toolbox based on inteins was absent in the registry nor did anyone establish a distributed computing platform before them).

The team provides compelling evidence that the **project works** (**aspect 3**), and in a variety of contexts, which is a significant **accomplishment** (**aspect 4**) - many teams demonstrate proof of principle in a single context only, and few as well and as quantitatively as seen here.

Regarding the **design** (**aspect 6)** of the circularization system: the team has considered not only the Biobricks but the 3D structure of the protein and the appropriate properties of the linker.

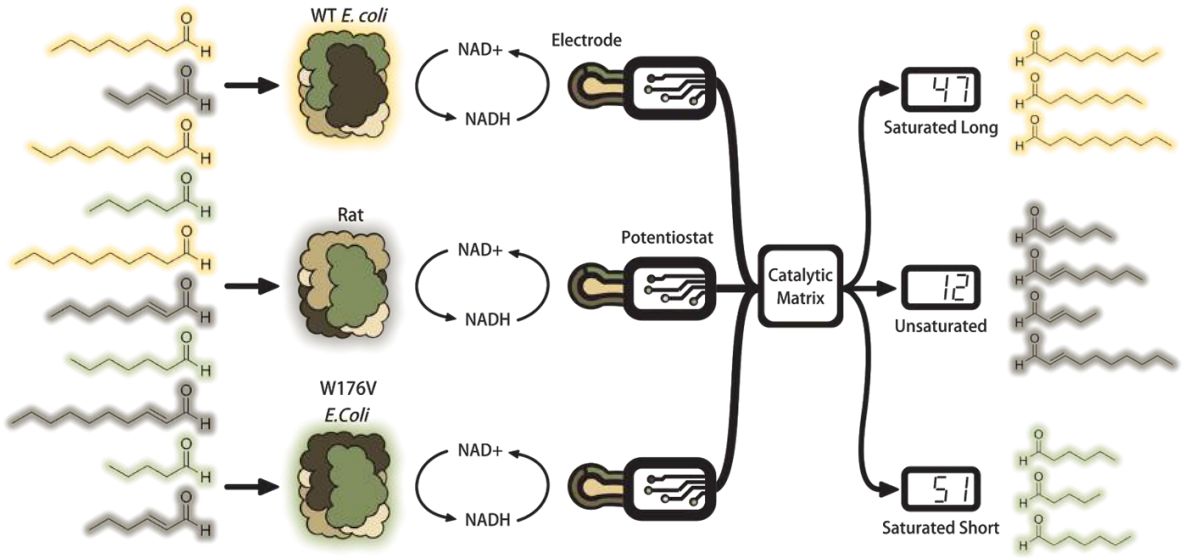
Their model for linker design is new (so is the concept of using rigid linkers the software is based upon), and by making it available online, the team makes it more likely that this generalized system for improving protein stability will have an **impact** (**aspect 5**) through its use by future iGEM teams and other research teams.

Moreover, Heidelberg used concepts of standardization and modularity in creating all the constructs of their intein toolbox.

To summarize, Heidelberg 2014 created an incredible project that thoroughly impressed the judges. Their presentation room at the 2014 Jamboree was filled beyond capacity, as the team is well known to demonstrate a high level of achievement in iGEM after also winning in 2013.

UC DAVIS 2014

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 nicely addressed by their project.

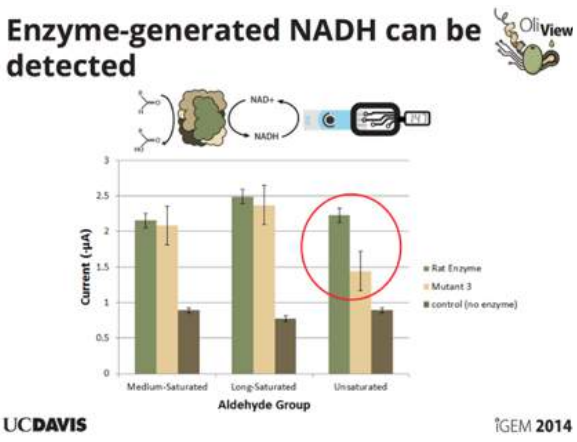
How much did the team accomplish (aspect 4)? Did the project work (aspect 3)?

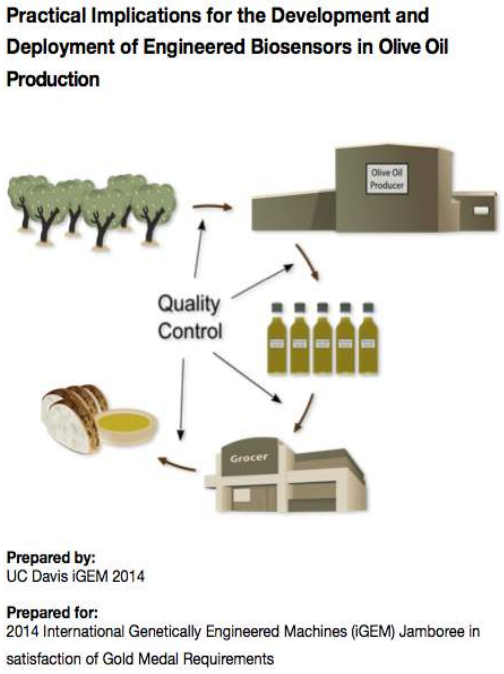
First, they identified NAD+ dependent aldehyde dehydrogenases with unique specificity profiles from online databases and designed 20 mutants of E. coli aldehyde dehydrogenase. They developed a simple spectrophotometric plate assay which measured the concentration of NADH in a solution. Using this assay, 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 (*see Case Study in the Hardware section*).





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).

How thoughtful and thorough was the team's consideration of human practices (**aspect 7)**?
To satisfy the gold medal requirement, 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. Here's the title page from their whitepaper:

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. Here's what the judges had to say:

"…The Policy and Practices is completely integrated with the project and the motivation and driving force for OliView…"

"…You clearly integrated your policy and practices into the overall project. The end-to-end work from science to technology development was especially impressive…"

"…All of their work pointed to the central question of the tier project. They explored the market, the legislation and the science of the rancid olive oil. Their report demonstrates a superior depth of thought and analysis."

How impressive is this project (aspect 1)?
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. This comment from one of the judges describes their accomplishments very nicely:

"Your team is a top-notch example of a successful iGEM team and project…Not only have you succeeded in obtaining a 360 degree view of the labeling and testing standard of olive oil produced in California, you have effectively used engineering and design principles to produce a device that is convincingly functional, and promises to have a big impact on the field…"

SPECIAL PRIZES

Special Prizes

Special prizes are awarded to teams in iGEM who excel in focus areas of the competition. All teams are eligible for special prizes and they will be distributed by section. Special Track teams are not eligible for the corresponding special prize; for example, the 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 deemed of sufficiently high quality to warrant distributing the award by the judges**
3. **A high enough number of judges vote for the special prize in question (please pay attention to the number of judges in front row in the room during presentations)**

To reiterate, all information regarding special prize eligibility should be found on the appropriate static wiki page as described above. If the information is not found there, then a team will be considered ineligible for that prize.

The iGEM 2017 Executive Judging Committee hopes to award the following special prizes, conditional on the accomplishments presented by the teams:

1. **Best Advancement in Plant Synthetic Biology**
2. **Best Applied Design**
3. **Best Education and Public Engagement**
4. **Best Hardware**
5. **Best Measurement**
6. **Best Integrated Human Practices**
7. **Best Model**
8. **Best New Basic Part**
9. **Best New Composite Part**
10. **Best Part Collection**
11. **Best Poster**
12. **Best Presentation**
13. **Best Software Tool**
14. **Best Supporting Entrepreneurship**
15. **Best Wiki**

Pages for Evaluating Special Prizes NEW

Teams need to complete the following pages to compete for the specified award.

Applied Design	**http://2017.igem.org/Team:Example2/Design**
Education and Public Engagement	**http://2017.igem.org/Team:Example2/Engagement**
Hardware	**http://2017.igem.org/Team:Example2/Hardware**
Measurement	**http://2017.igem.org/Team:Example2/Measurement**
Model	**http://2017.igem.org/Team:Example2/Model**
Part: Basic	**http://2017.igem.org/Team:Example2/Basic_Part**
Part: Composite	**http://2017.igem.org/Team:Example2/Composite_Part**
Parts Collection	**http://2017.igem.org/Team:Example2/Part_Collection**
Software Tool	**http://2017.igem.org/Team:Example2/Software**
Supporting Entrepreneurship	**http://2017.igem.org/Team:Example2/Entrepreneurship**
Plant synthetic biology	**http://2017.igem.org/Team:Example2/Plant**

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. If their page has been edited but they are not pre-selected to be judged, not removing the following .html may be the problem:

Awards with no required standard page

- Best Wiki
- Best Poster
- Best Presentation
- Track Awards (based on total body of work, not any specific page)

Advancement in Plant Synthetic Biology NEW

Many teams have worked on plant projects in iGEM, starting as far back as 2010. Much like with Hardware, teams have competed with plant projects even if they were not aiming for a specific award. After years of seeing plant projects, iGEM HQ is supporting plants this year in conjunction with the **Open Plant Initiative**. We are working on supporting plant parts, known as **Phytobricks**, and a number of those parts were included in the 2016 Distribution.

Plant teams could tackle a wide variety of projects across many tracks and as such, we are supporting plants as a special prize, not a track. Teams have submitted parts from multiple plant chassis and we have a collections page on the Registry with more information: **http://parts.igem.org/Collections/Plants**.

The Advancement in Plant Synthetic Biology special prize is judged according to the following aspects:

1. **How impressive was the use of a plant chassis?**
2. **How impressive was the collection of parts made for the plant chassis?**
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?**

The plant award is new in 2016, so we don't have any previous projects that were assessed using this rubric. There is also no specific static page associated with the plant award on team wikis, so you will need to do your best to evaluate these teams.

We have a lot of previous projects that you can check out to see what has been done with plants in iGEM in the past:

- **2010 Nevada (Nico@ana tabacum) Development of Plant Biosensors for Environmental Monitoring**
- **2010 Harvard (Arabidopsis thaliana) iGarden: An Open Source Toolkit for Plant Engineering**
- **2011 UEA-JIC_Norwich (Physcomitrella patens) The EvoluNon of SyntheNc Biology; The IntroducNon of New PhotosyntheNc Eukaryotes as Model Organisms**
- **2012 Kyoto (Arbidopsis thaiana) Flower Fairy E.coli**
- **2013 TU-Munich (Physcomitrella patens) PhyscoFilter**
- **2014 BIOSINT Mexico (Arabidopsis thaliana) Green Demon**
- **2014 Cambridge JIC (Marchan@a polymorpha) mösbi - The plant Biosensor for Everyone**
- **2014 Concordia (Chlorella vulgaris, Chlorella kessleri and Chlamydomonas reinhard@i) Clean, Green Lipid Machines**
- **2014 Hannover (Arabidopsis thaliana) Plant Against**
- **2014 NRP UEA (Nico@ana benthamiana) Green Canary**
- **2014 UESTC China (Nico@ana tabacum) Plants vs HCHO**
- **2014 Valencia UPV (Nico@ana benthamiana) The Sexy Plant**
- **2014 Toulouse (Nico@ana benthamiana) SubN Tree**
- **2015 Georgia State (Nico@ana tabacum) P4:Protein, Products, Pichia, Plants**
- **2015 Waterloo (Arabidopsis thaliana) CRISPier**
- **2015 NRP-UEA (Nico@ana benthamiana) House of Carbs**
- **2015 Valencia UPV (Nico@ana benthamiana) AladDNA**

Applied Design

Summary:
The focus of Applied Design is the development of a synthetic biology product.
Excellent teams will address the “big-picture” perspective of the product in addition to making it.

The Applied Design prize is awarded to the team that has developed a synthetic biology product to solve a real-world problem in the most elegant way. The students will have considered how well the product addresses the problem versus other potential solutions, how the product integrates or disrupts other products and processes, and how its lifecycle can more broadly impact our lives and environments in positive and negative ways.

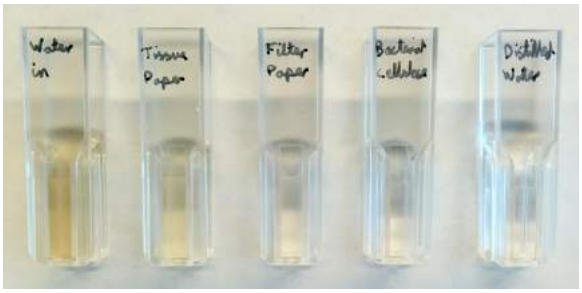
Applied design projects are judged on the following aspects:

1. **How well did the project address potential applications and implications of synthetic biology?**
2. **How creative, original, and compelling was the project?**
3. **How impressive was the project installation in the Art & Design exhibition space?**
4. **How well did the team engage in collaboration with people outside their primary fields?**

Imperial College London 2014

This team used bioengineered bacterial cellulose, commonly associated with kombucha, to create a water filtration system.

The team engineered the bacteria to produce metal binding enzymes, which would better capture metals like zinc and nickel as water passed through the filter (**aspects 1 and 2**).



The project was impressive in a number of ways. The team members worked with designers to brainstorm applications for their bacterial mat before settling on water filtration as their goal. Crucially, they also met with experts in the field of water purification—including Thames Water, a private utility company responsible for water supply and wastewater treatment in large parts of London, to more deeply understand the problem they were trying to solve and understand how their project might fit into existing infrastructures (**aspect 4**).

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. Some teams have virtually specialized in hardware devices, even if they was no specific prize to reward their efforts. In 2014, iGEM introduced a microfluidics track that was the first official recognition of hardware in the iGEM competition. As it was quite heavily constrained, we only saw participation from two teams. In 2015, the track name was changed to Hardware, the over-specification was relaxed and participation increased to **seven teams**.

Beginning in 2016, the Hardware special prize was introduced to reward standard 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 rubric, where the language is tailored more exactly to the nature of the prize.

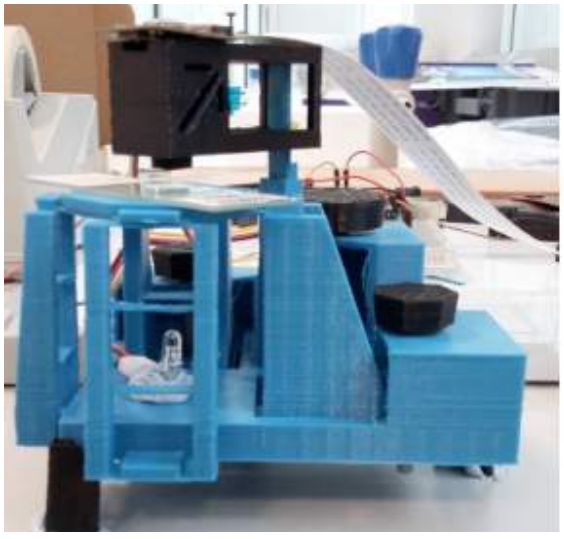
In the case of the Hardware special prize, the rubric aspects are as follows:

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?**

Cambridge-JIC 2015

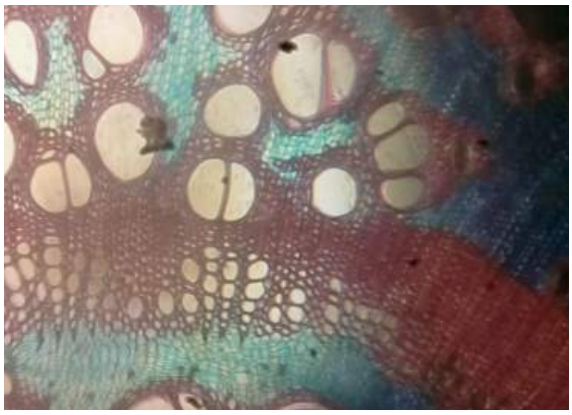
Cambridge-JIC developed an open-source, low-cost, 3d printed microscope based on a Raspberry pi computer and camera named the “Openscope”. It can be difficult to get access to microscopes, so the problem they chose to solve is creating a low-cost variant that almost anyone can build for their lab using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

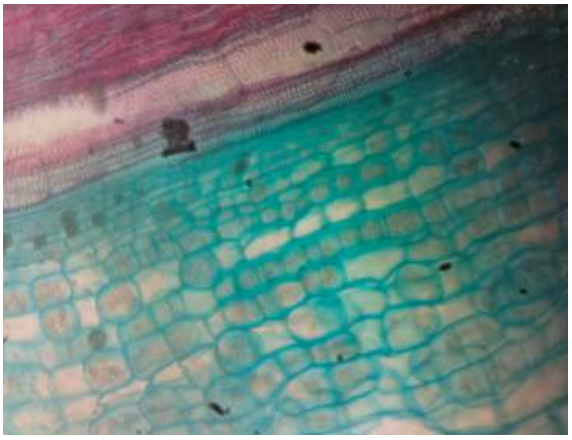
Cambridge-JIC worked hard to create a comprehensive bill of materials (BOM) so others can assemble materials to easily reproduce the device:
http://2015.igem.org/wiki/images/d/d0/CamJIC-OpenScope-BOM.pdf



They also provided all documentation and 3d print files to reproduce their scope in a convenient location:
http://2015.igem.org/Team:Cambridge-JIC/Downloads

Cambridge open scope and two brightfield images acquired using the prototype





Sherbrooke 2015

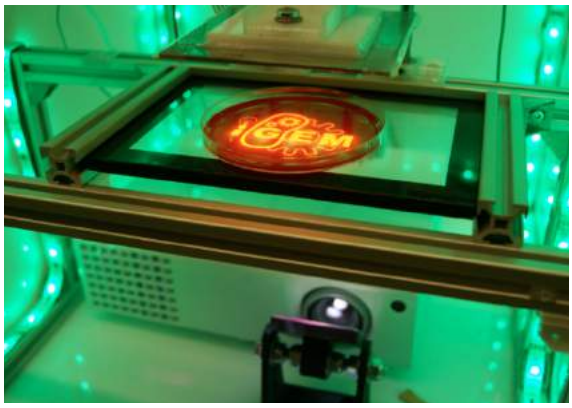
This team designed and built a giant robotic assembly platform that they brought to the Jamboree. The platform area was 160 x 130 x 120 cm, taking up two entire tables in the hardware expo space. Sherbrooke aimed to create a modular general lab automation platform that was low enough cost for any lab and grad student to have one available.

They designed a series of modules to function with their platform, such as single and multi-channel pipettes, grippers, heating/cooling functions and magnetic bead agitation.
Specifications for their open source modules can be found on their design page:
http://2015.igem.org/Team:Sherbrooke/Design

Team Sherbrooke demonstrating their robot at the 2015 Giant Jamboree

TU-Darmstadt 2015

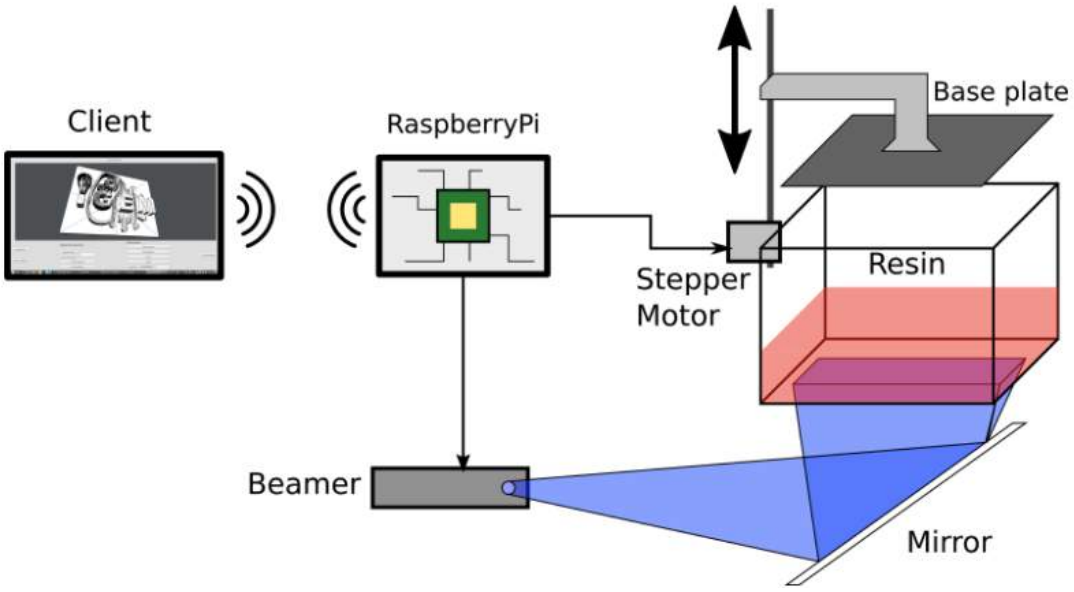
The TU-Darmstadt team designed and built a 3d printer from the ground up. Instead of building a more common fused deposition modelling printer, they built a stereolithography printer that uses a UV emitting projector and a photosensitive resin. The team built the printer, the software, a web-based RNA riboswitch design site, and a social portal for networking and also designed a biological photosensitive resin that would work in their printer.



The team provided part files and a bill of materials to enable others to recreate their work:

http://2015.igem.org/wiki/images/9/9b/TU_Darmstadt_tech_customPrinterParts.zip

http://2015.igem.org/wiki/images/f/ff/TU_Darmstadt_tech_instructions.pdf



Human Practices

Summary:
Human Practices (HP) describes the "bigger picture" part of iGEM. Through HP teams must convince the judges that they have thought carefully and creatively consider whether their projects are safe, responsible and good for the world. This involves teams exploring issues related (but not limited) to the purpose, desirability, ethics, safety, security, and sustainability of their projects. These issues are complex and often don't have simple answers. Teams therefore often conduct public engagement and dialogue; educating while inviting public input to shape the direction of their work.

We expect all teams to attempt some HP work. HP work is mandatory for a Silver Medal and additional work in this area is one option to work towards qualifying for a Gold medal. See the medal criteria section for additional details.

There are two special prizes for HP: Best Integrated Human Practices and Best Education & Public Engagement.

The **Best Integrated Human Practices (HP)** prize recognizes exceptional work based on the gold medal requirements for Human Practices (see medal criteria). To qualify for this award, teams must demonstrate to the judges how their investigation of HP issues has been integrated into the design and/or execution of their project in a thoughtful and creative way.

- When engaging various stakeholders the teams should demonstrate a dialogue was established ***throughout*** the design, execution, and presentation of their project.
- The idea of ***why*** their project is important and ***how*** it should be executed should be developed and answered by their HP interactions.

The Best Education and Public Engagement (EPE) prize recognizes exceptional work based on an educational program and/or public engagement activity. For this prize, activities do not have to be directly related to the team's project (as is expected for the Integrated Human Practices prize and gold medal requirement), but may look at wider issues related to iGEM or synthetic biology.

- It is ***not*** for "proselytizing" iGEM and synbio by telling the community that iGEM is great and will "save the world".
- Great EPE projects will focus on establishing a dialogue or sparking new scientific interest in the community relating to synthetic biology

Teams select which prize(s) they are competing for by completing the relevant page(s) in their wiki. Separate static wiki pages should be used to describe accomplishments for:

- HP for Silver medal
- HP for Gold medal and Best Integrated Human Practices (*Note: Teams can fulfill a gold medal criterion (gold #1) and compete for the integrated HP award within this single page.)
- HP for Best Education & Public Engagement

Best Integrated Human Practices

Teams competing for this prize should examine important questions beyond the bench related to (but not limited to) ethics, sustainability, social justice, safety, security, environmental impact, or intellectual property rights. Judges should evaluate whether a team can demonstrate that they have investigated, addressed and integrated one or more of these issues into the design of their project (typically the "lab" component or final application). **Teams should be evaluated on how well they can demonstrate that the results of this investigation are fully integrated into the design, execution and presentation of their project.**

The team should be able to document how their project evolved based on the information acquired from these activities. While methodology is important, it should not necessarily be the focus of the judge's evaluation. Focus on WHY the team has chosen their specific activities, WHAT they have done and accomplished, and HOW it has been integrated into the "wetlab" portion of their project.

More specifically, the current iGEM rubric contains four aspects for evaluating the Best Integrated Human Practices prize. These questions have been updated from the 2016 Jamboree to incorporate the changes made to the requirements in human practices:

1. **Was their work integrated into their project? (We want to see how projects have evolved based on Integrated HP work.)**
2. **Does it serve as an inspiring example to other teams?**
3. **Is it documented in a way that other teams can build upon?**
4. **Was it thoughtfully implemented (i.e., did they explain the context, rationale, prior work)?**

A few examples of exceptional human practice work from previous years can be found below:

Edinburgh 2015

The 2015 Edinburgh team challenged themselves with human practices by the nature of the project they developed; drug testing kits which identify the purity of drugs; illegal and recreational, in order for drug users to identify the substances they would be taking. Therefore in addition to the biosafety, biosecurity and societal implication of the "synthetic biology" component of their project, the team also had to address the societal implications of providing drug users with a test to identify purity of the drugs they were planning to take.

To accomplish this feat, the team developed an integrated program which fed back into the design of their biosensor by engaging with the general public, policymakers, ethicists, drug recovery specialists, and potential end users of the device. These dialogues were then reintegrated back into the design of the biosensor. It was both the breadth of discussions that the team had outside the lab and how they integrated those discussions back into the design of their biosensor that impressed the judges.

Bielefeld CeBiTec 2015

The 2015 Bielefeld team's project was designed to produce paper testing strips to identify heavy metals in water and separately to test drinks for potential date rape drugs. Their **integrated human practices project** consisted of two separate projects. 1) **Scenarios in form of newspaper articles based on actual news and interviews with experts.** 2) Analysis of the **dual use and biosecurity implications** of their project based on the current laws and recommendations from the international community.

Both aspects of their HP project integrated their wet lab work into the questions they explored and subsequently the information they gained from their HP project fed back into the design of their final application. It was the integration of their "wetlab" work into the design of their HP project and then taking the results of their HP work and integrating that back into the final design of their iGEM project that most impressed the judges.

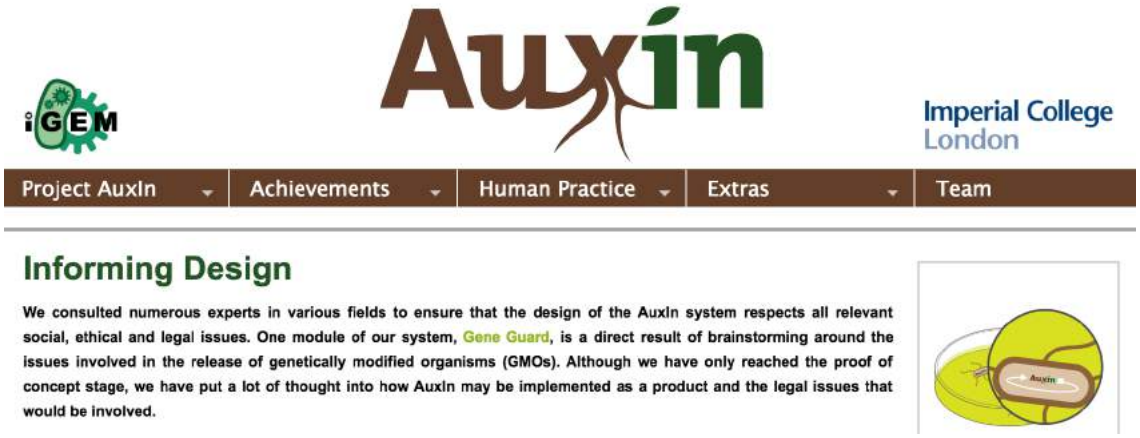
Imperial College London 2011

The 2011 Imperial College London team focused on HP work that would inform the design and implementation of their overall project, which was about engineering bacteria to help fight soil erosion and desertification. Impressively, the team gave equal weighting to experimental work, modeling, and HP.

The team was interested in scoping out a variety of ethical, legal and social issues that might specifically influence the design and implementation of their Auxin system (**aspect 1**). This is summarized nicely in the introductory paragraph to their HP work (**aspect 3)**.

To achieve this, they consulted with a range of stakeholders with different and relevant expertise, including companies, plant scientists and charities concerned with desertification (**aspect 4**). This is an appropriate method for the team to choose in the early design stages of a project, when they were trying to get a sense of key parameters, constraints and opportunities (**aspects 1 and 4**).

By consulting experts based in different settings (academia, industry, NGO), the team was also able to incorporate multiple perspectives into the design of their system (**aspect 4**). The team provided nice clear summaries of these discussions, and included photos of the event (**aspects 2 and 3**).



Chassis choice

1. Goal

In chassis choice, we had to consider several aspects. We wanted to choose a chassis that we would be able to transport to arid areas, preferably already enveloped inside a solid seed coat. In addition, we want the bacteria to be able to persist in the soil long enough to carry out their function. On the other hand, we also wanted to prevent spread of the bacteria into far-away ecosystems where they are more likely to have a detrimental effect on the ecological balance.

2. Action

We consulted two ecologists who are experts in above/below ground interactions and soil microbial ecology. They both advised us that while it may be more obvious to use naturally occurring soil bacteria such as *Bacillus subtilis*, *Escherichia coli* is less likely to survive in soil and may ensure better containment. **Dr Alexandru Milcu** pointed out that this is especially important considering that very high auxin secretion may skew plant populations. While this is not an issue in areas where the ecosystem is already badly affected, spread to other ecosystems, especially via spores, is a big issue. **Dr Robert Griffiths** also advised us that while engineering naturally occurring soil bacteria might lead to better persistence and cause our project to be more efficient, containment would be more easily achieved by using bacteria that do not normally occur in soil such as *E. coli* as they are more likely to be outcompeted.

Bacteria	Pro	Con
E. coli	Does not form spores, easier to contain, but has been surviving in the soil for more than 3 weeks without antibiotics	Difficult to implement in seed coat
B. subtilis	Spores are easy to incorporate into seed coat, give capacity for long term persistence	Spore-forming, can blow into other ecosystems and influence them negatively

Figure 1. Our reasons for choosing E. coli *as our chassis (graphic by Imperial College London iGEM team 2011).*

These arguments caused us to pin-point our chassis choice on *B. subtilis*, a natural spore-forming bacterium that naturally occurs in soil and *E. coli*. We initially codon-optimised our genes for both of these species. At the first human practices panel, we thoroughly discussed the advantages and disadvantages associated with both chassis choices **(Figure 1)**.

3. Result

Containment and possible contamination of other areas is a very big human practices issue. With *B. subtilis* as our chassis we would never be able to ensure complete containment. On the other hand, enveloping *E. coli* in a seed coat is mostly a mechanical issue that we should be able to overcome. We therefore chose to use *E coli* as the chassis for AuxIn.

The team also outlined very clearly how these consultations influenced their further HP activities (**aspects 1 and 3**), for example (i) the investigation of legal issues surrounding the release of genetically modified organisms, and (ii) the design of a 'Gene Guard' containment device with the aim of preventing horizontal gene transfer. Throughout their description of the Gene Guard, they made clear links between their understanding of the broader context of application and the technical design choices they were making. This is a nice example that shows how HP work can inform aspects of the project's technical design in clear and appropriate ways (**aspects 1 and 4**).

As exemplified in the figure above, the HP information is very clearly presented on the team's wiki, making it easy for judges to see what work they have done and why (**aspect 3**). The overall aim and description of the HP work ('Informing Design') remains at the top of each wiki page relating to HP, keeping a nice tight focus.

Crucially, the team also did a good job of narrating their HP work to help judges understand exactly how each HP activity has influenced their thinking and actions regarding their project (**aspects 1 and 3**).

Overall, the team did a significant amount of HP work (**aspect 4**), exploring a wide range of legal, technical, and social questions relating to the potential implementation of their Auxin system, and consulting several relevant experts who could help inform different types of choices within their project design.

Importantly, the team was also aware of the limitations of their work, making it a nice example for others to pick up and build on (**aspects 2 and 4**). For example, they highlighted up-front that this is proof-of-concept work, and they also noted on their wiki that 'kill switches' are never 100% effective, and explain how their containment device is an attempt to improve on existing technologies (but is not a silver-bullet solution).

The team's approach to engaging with HP topics throughout their project was encoded in a detailed implementation plan. While previous teams had experimented with various elements of this approach, the Imperial team's thoroughness, clarity, and combination of methods was considered by the judges to be a novel contribution to methods and understanding that could be adapted by other teams (**aspects 2, 3 and 4**).

From the above, we can see why this HP project earned a high score from the judges. The team did a lot of work, and importantly they did a great job at explaining what they did and why they did it, and what effect it had on their thinking as their project progressed.

Best Education and Public Engagement

Best Education and Public Engagement projects should involve innovative educational tools and public engagement activities that have the ability to discuss the science behind synthetic biology, spark new scientific curiosity, and establish a public dialogue about synthetic biology with and from voices outside the lab.

These projects should NOT be about proselytizing how great iGEM is or how synthetic biology can save the world. Projects may not necessarily have anything to do directly with teams' "wetlab" work. Judges should focus their evaluations on whether a dialogue was established between the team and the public.

Teams should be able to demonstrate that this dialogue was bi-directional, - teams should be able to demonstrate that they have learned from the interaction and/or that the opportunity for learning was built into the activity. Judges should focus on WHY the team has chosen their specific activities, WHAT they have done and accomplished, and HOW they have learned from the activity.

More specifically, the current iGEM rubric contains four aspects for evaluating the Best Education and Public Engagement prize. These questions were updated for the 2016 Jamboree and ALL judges should evaluate a team's Education and Public Engagement activities.

1. **Did their work establish a dialogue?** (The teams should show that a conversation was established, that they did not just "talk at" their audience.)
2. **Does it serve as an inspiring example to other teams?**
3. **Is it documented in a way that others can build upon?**
4. **Was it thoughtfully implemented (i.e., did they explain the context, rationale, prior work)?**

The HP committee has provided links to some excellent past projects on the **Human Practices Hub** which exemplify work in Best Education and Public Engagement activities. It is important to note that in previous years, teams have not been asked to explicitly separate these activities, and so have not been judged on exactly the same criteria listed above. But the overall approach of the exemplary projects we have identified captures the spirit of good Education and Public Engagement work.

William and Mary 2015

The 2015 William and Mary team provides an excellent example of a complete and thorough Education & Public Engagement project. While the education and public engagement activities did not directly relate to their "wetlab" work, they developed educational activities and kits based on feedback from public workshops they held in order to understand the public's understanding, concerns and hopes for synthetic biology.

They developed 24 activities into an educational booklet which lists the procedure, background information, materials and cost for the activity, critical learning questions, and learning goals.

An effort was made to keep the activities low-cost and based on materials easily accessible to teachers, making them adaptable for any age or educational background. The activities are also designed so that teachers with limited biology background could easily run them. One particular aspect of the project that impressed the judges was the ability of the teaching tools to be used by others and adapted in the future.

Marburg 2014

The 2014 Marburg team is an excellent example of an innovative educational tool and public engagement activity that had the ability to discuss the science behind synthetic biology, spark new scientific curiosity, and establish a public dialogue from voices outside the lab. The city of Marburg is home to one of the only schools in Germany for the visually impaired. This team re-designed their own lab experiments in order to enable these visually impaired students to participate in the lab, by converting what they were seeing under the microscope into sound (**aspects 1 and 3**). They demonstrated not only why they designed these activities but also demonstrated how the activity changed their own perceptions on science (**aspect 5**).

Other notable engagement projects

BGU Israel 2014 set up clinics and scholarship programs that would outlast their iGEM participation (**aspects 2 and 3**).

Aachen 2014 developed a series of modules for introducing synthetic biology to high schools (**aspects 1 and 4**).

Purdue 2012 and **Purdue 2013** created a community lab (sought non-profit status) as well as a biotech badge for the Girl Scouts of America (**aspects 1 and 3**). The latter activity was done in response to a STEM report released by the Girl Scouts of America. This effort demonstrates how a team used outreach to address a gap that another community identified (**aspect 2**). These efforts aren't continuing now, but they were good examples of ways to attempt to make lasting impacts.

Innovation in 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.
- Participation in the InterLab Study is strongly encouraged.

There are a lot of exciting parts in the Registry, but many parts have still not been characterized. The Innovation in Measurement prize seeks to award efforts to tackle this challenge. Examples of activities that exemplify "Innovation in Measurement" include (but aren't limited to) designing great measurement approaches for characterizing new parts or developing and implementing an efficient new method for characterizing thousands of parts. Teams interested in competing for the Innovation in Measurement prize are strongly encouraged to participate in the **Measurement InterLab study**.

When judging for the Innovation in Measurement prize, there are five aspects in the rubric upon which a team's score is based:

1. **Is the measurement potentially repeatable?**
2. **Is the protocol well described?**
3. **Are there web-based support materials?**
4. **Is it useful to other projects?**
5. **Was a standard reference sample included?**

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 could include:

Novelty:
Did the team develop a new way to measure their part? Did they build a measurement instrument? Or did they apply an existing measurement assay or tool in a new and innovative way to take their measurement? Many teams take a creative and innovative approach to measurement. Teams that approach measurement with (a) a new tool, instrument, or assay, or (b) a new way to utilize an existing method, and then show that their approach works as expected, have achieved excellence in measurement.

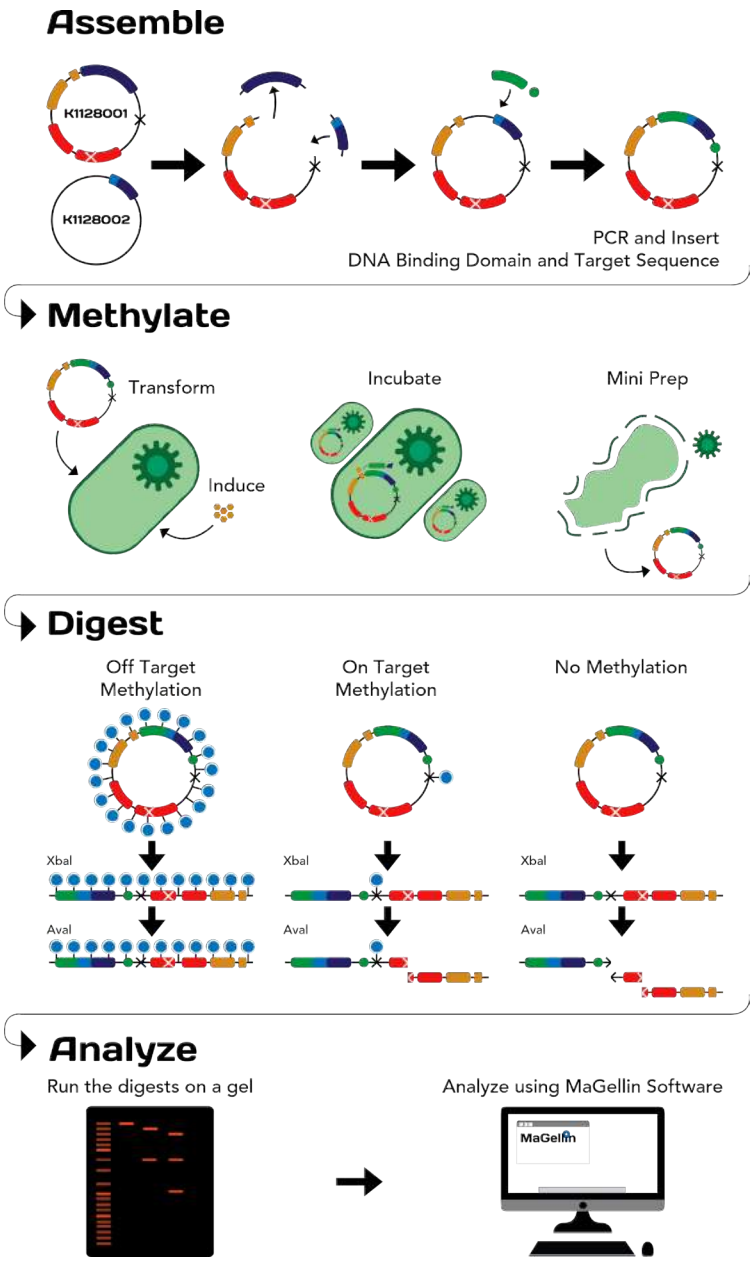
Comparison to similar approaches:
Did the team approach the measurement of their part from various angles? Did they attempt multiple assays? Did they compare their new tool/instrument/assay with an established one? When teams strive for excellence in measurement, they should also make sure they take 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.

Penn 2013

Best BioBrick Measurement Approach

The Penn 2013 team focused on accelerating the development of an epigenetic engineering toolbox (workflow shown at the left). The team developed MaGellin, a novel assay to test and characterize the utility of various DNA binding domains to enable sequence-specific methylation. The assay was built into one modular plasmid and was validated in vitro and in vivo (**aspects 1 and 5**).

It will simplify the workflow for synthetic biology labs with an interest in using DNA methylation as a control layer before transcription (**aspect 4**). They also developed a software package that automatically analyzes and interprets data from the assay, facilitating and accelerating the rate of characterization. A highly detailed protocol was available on their wiki (**aspect 2**), including supporting data (**aspect 1**).



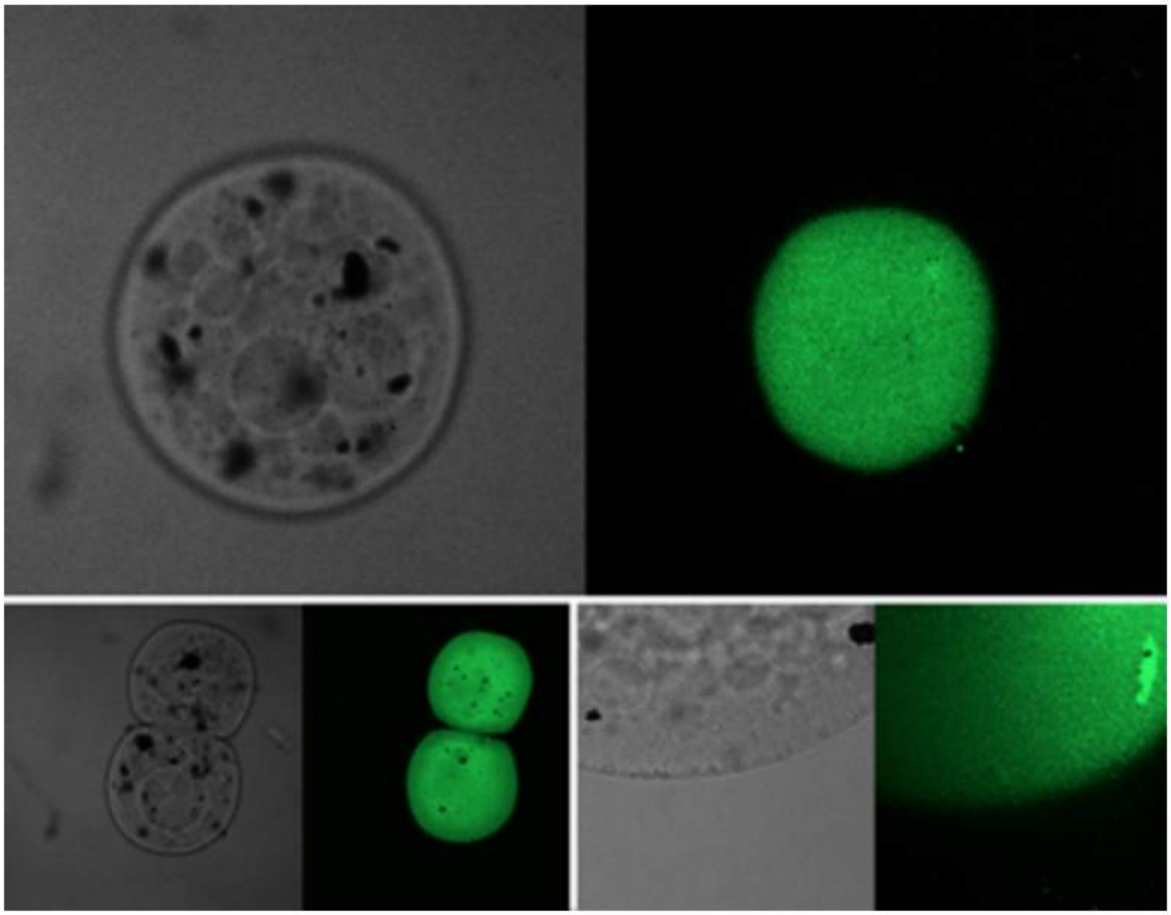
Toulouse 2014

Best Measurement Approach, Undergraduate

The Toulouse team developed a new protocol to test the chitin binding ability of their system using chitin magnetic beads. This test allowed the team to characterize their genetic device that had a chitin-binding domain in it, and they felt confident that it could be used with other BioBricks that display a chitin-binding domain on the surface of a cell (**aspect 4**).

The great advantage of the test is that it allows quantification of the number of cells expressing the chitin-binding domain through the use of a simple serial dilution, plating, and colony counting protocol (**aspects 1 and 2**).

The team also validated that the bacterial cells expressing chitin were attached to the chitin-coated magnetic beads using microscopy (as shown on the left). Through the use of a green fluorochrome (Syto9), they showed the presence of bacteria on the surface of the beads (**aspect 5**).



Model

Summary:

- A model is a (usually mathematical) representation of a project (or part of a project) that should in some way contribute to project design or understanding.
- Excellent models will have ***well-documented development***. This means that you should 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
- Even if the models seem “mathy”, these basic points should be easily understood.

Many (but not all) teams will construct mathematical 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 mathematical modeling?**
2. **Did the model help the team understand their part or device?**
3. **Did the team use measurements of the device to develop the model?**
4. **Does the modeling approach provide a good example for others?**

Colombia Uniandes 2013

Let's consider a few examples. 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.
While **Colombia Uniandes 2013**'s approach was not unique, they distinguished themselves by careful consideration and research of their model parameters - citing each and lending credence to the veracity of their model.

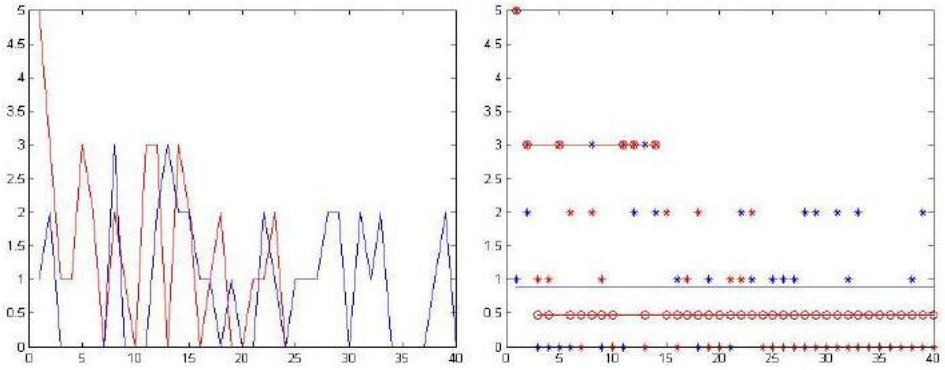
(In iGEM, as in life, one encounters many models composed almost entirely of educated guesses masquerading as parameters.)

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

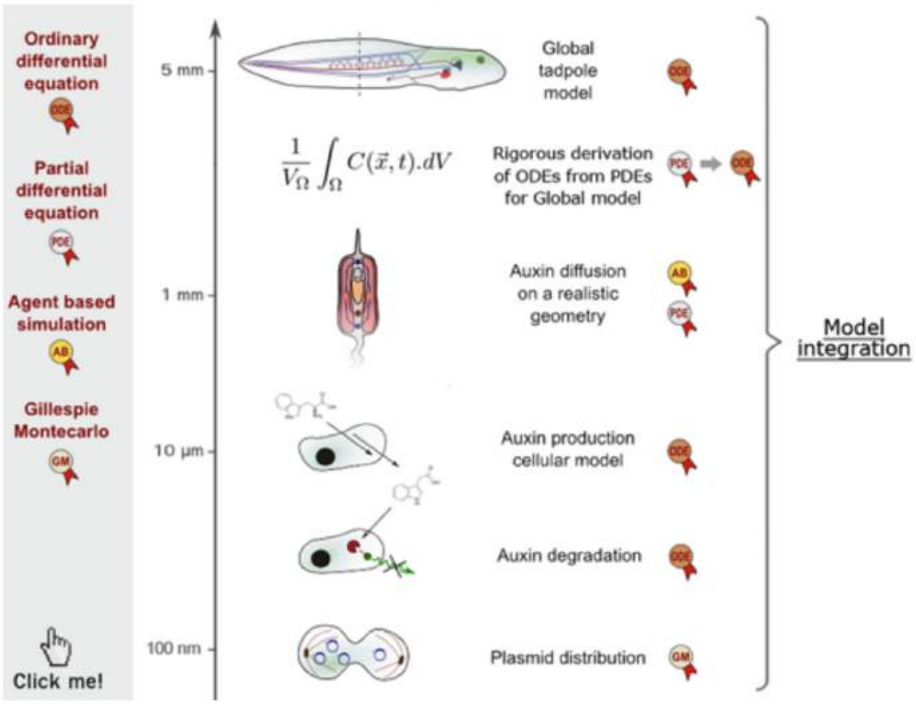
OUC-China 2013

Team **OUC-China 2013** performed a simulation of the behavior of bacteria with an artificial magnetic organelle in a magnetic field. Their physical 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).



Evry 2012

Team **Evry 2012** drew notice for generating a number of different models - using various techniques to model their system at a variety of length scales. This alone would have been impressive, but their work to integrate the various models - connecting them so that in the end measurable behavior could be modeled according to a series of interconnected models - was considered especially praiseworthy.



KU Leuven 2013

Likewise, **KU Leuven 2013** 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 one of the examples: **KU Leuven 2013**.

KU Leuven performed **flux balance analysis**, solved for a system of **ordinary differential equations (ODEs)** searching through a reasonably broad parameter space, and considered **physical convection** 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 (**aspect 1**). 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 (**aspect 2)**. The practical results of their convection model are less clear, because of the number of unknowns, but the team lets us know that they haven't 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 (**aspect 3**). 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 (**aspect 4**).

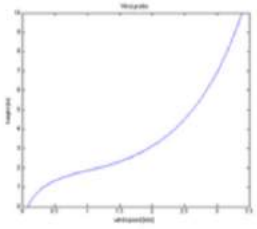


Figure 1 I Wind profile for a crop height of 2 m and a wind speed of 3.39 m/s at a height of 10 m.

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.

Parts: Basic, Composite, and Part Collection

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)
  - Collections should exemplify a ***system*** of parts that can be applied to other situations by other teams (e.g., framework for a measurement system)
- 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.

While a basic BioBrick part composes a single functional unit, a composite part is an integrated assembly of interchangeable components that can function with some versatility, linking its elementary functions (transcription, translation, encoded protein) together to give a higher order function (regulatory device). There are four aspects in the current rubric for assessment that we should keep in mind as we evaluate parts (with minor differences for basic and composite parts):

1. **Basic Parts: How does the documentation compare to BBa_K863006 and BBa_K863001?**
2. **Composite Parts: How does the documentation compare to BBa_K404122 and BBa_K863005?**
3. **How new/innovative is it?**
4. **Did the team show the part works as expected?**
5. **Is it useful to the community?**

In 2014, the part status check system was incorporated into the part evaluation system. Judges now no longer need to individually look at each base pair to examine if it meets Registry standards. As this check is now automated, judging parts comes down to the quality of documentation, innovation, functionality and utility to the community.

To satisfy Registry guidelines, the part must (1) be sent to iGEM HQ by the deadline (see calendar of events for the deadline), (2) be in the pSB1C3 vector, (3) be BioBrick (RFC10) compatible or an agreed exception (on a case-by-case basis), (4) meet the standards set by the safety committee, and (5) be documented on the part 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

main page | design | experience | information | part tools | edit

Part:BBa_K863006

Designed by: Isabel Huber Group: iGEM12_Bielefeld-Germany (2012-09-18)

Coding

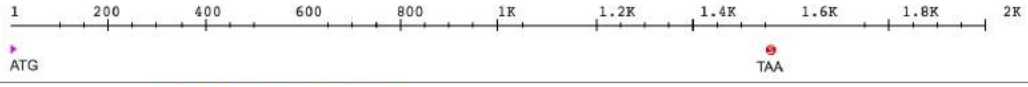
Released HQ 2013
Sample In stock
Experience: Works
Not Used
Get This Part

ecol laccase from E. coli

E.coli laccase ORF

Sequence and Features

Subparts | **Ruler** | SS | DS **Length: 1551 bp** View plasmid Get part sequence.



Assembly Compatibility: 10 12 21 23 25 1000

Usage and Biology

In the last few years a lot of attention has been drawn to laccases due to their ability to oxidize both phenolic and nonphenolic lignin related compounds as well as highly recalcitrant environmental pollutants. This makes them very useful for applications concerning several biotechnological processes. This includes the detoxification of industrial effluents, for example from the paper and pulp, textile and petrochemical industries. Laccases are also valuable as a tool as a tool for medical diagnostics and as a bioremediation agent to clean up herbicides, pesticides and certain explosives in soil. Furthermore these enzymes are also used as

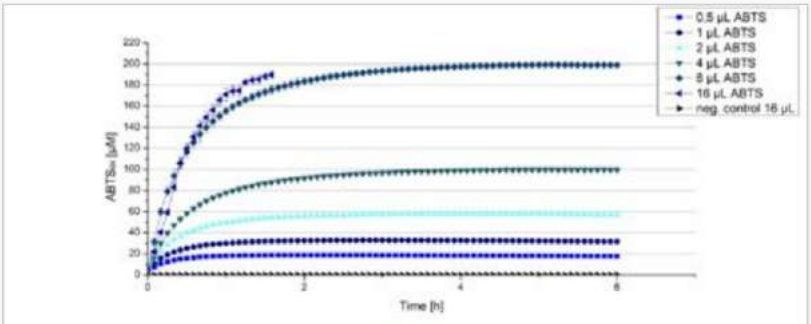


Figure 13: Analysis of ABTS oxidation by ECOL laccase tested with different amounts of ABTS. The higher the amount of ABTS the more oxidized ABTS can be detected.

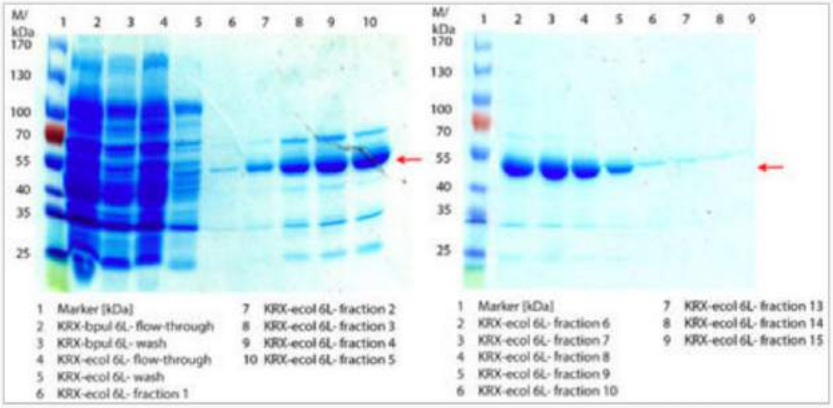
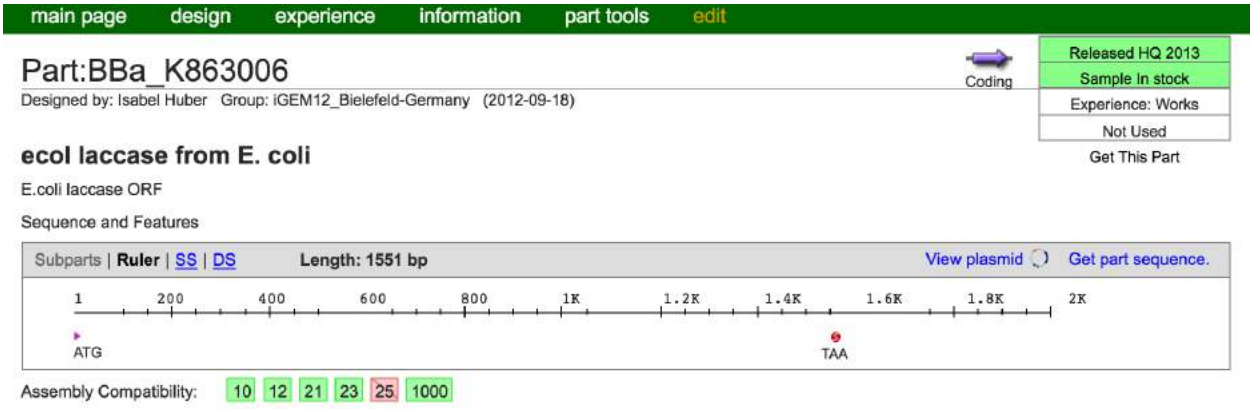


Figure 6: SDS-Pages of lysed *E. coli* KRX culture containing BBa_K863005 (fermented in a 6 L Bioengineering NFL22) after purification. The flow-through, wash and the elution fraction 1 to 15 are shown (except from fraction 11/12). The arrow marks the ECOL band with a molecular weight of 53.4 kDa.

As a sample part evaluation, let's look at **BBa_K863006**, a basic part which contains the open reading frame for *E. coli* laccase and was created by the **Bielefeld-Germany 2012** iGEM team. As seen in **aspect 1** of the rubric, this part is used to set an example for excellent documentation of parts, most of which can be found on the part main page (see figures below).

Not only is there a lengthy paragraph describing the basic biology behind the part and its main usage (which pertains to **aspect 2**, and includes a literature reference), but also there is extensive data describing purification, SDS-PAGE, MALDI-TOF analysis, and enzyme activity assays for the E. coli laccase under the control of T7 promoter with a His-tag (**aspect 3**, see **BBa_K863005** for additional information). Additionally, we can clearly see that this part is compatible with RFC10, as there is a green box labeled "10" next to "Assembly Compatibility" (see the red arrow). Therefore, this part is accepted in the part status check.

On the design page, we additionally find information about the source of the part and the primers that were used to isolate the gene, allowing other researchers to replicate the work:



Usage and Biology

In the last few years a lot of attention has been drawn to laccases due to their ability to oxidize both phenolic and nonphenolic lignin related compounds as well as highly recalcitrant environmental pollutants. This makes them very useful for applications concerning several biotechnological processes. This includes the detoxification of industrial effluents, for example from the paper and pulp, textile and petrochemical industries. Laccases are also valuable as a tool as a tool for medical diagnostics and as a bioremediation agent to clean up herbicides, pesticides and certain explosives in soil. Furthermore these enzymes are also used as catalysts for the manufacture of anti-cancer drugs and even as ingredients in cosmetics[1]. Their capacity to remove xenobiotic substances and produce polymeric products makes them a useful tool for bioremediation purposes. In our project laccases are used as cleaning agents for a water purification system. Laccases are copper-containing polyphenol oxidase enzymes **(EC 1.10.3.2)** that can be found in many plants, insects, microorganisms and mainly in fungi. These enzymes fulfill several functions in different metabolic pathways. Laccases are able to oxidize a broad range of substrates due to the contained copper-cluster, by reducing oxygen to water. The active site of the enzyme includes a four-copper-ion-cluster, which can be distinguished by spectroscopic analyses. This cluster consists of one blue copper-ion (type 1), one type 2 and two type 3 copper-ions. Because of the blue copper-ion, the laccases belong to the big family of the blue copper proteins. This specific blue copper ion is essential for the enzyme mediated radical oxidation of the phenolic groups. In this reaction the electron from the oxidation is transferred to the other three copper ions. These ions form a trinuclearic cluster, which transfers electrons to the terminal electron acceptor oxygen. By receiving four electrons the molecular oxygen is finally reduced to water.

For other examples of great parts, refer to the part numbers listed in the rubric aspects above. When looking at parts, you should also keep in mind that many parts (including some of the best parts) suffer from somewhat insufficient documentation.

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:

- Missing link to team's wiki page to read more about the part in context of the project
- Figure axes and legends lacking important details about how the data was obtained (e.g., strain and expression plasmid for protein-coding parts); the data on the Registry page should be able to stand alone, if possiblel
- Links to UniProt or other database for original sequence or literature references not provided for parts derived from a natural source
- Information about which device (with a promoter, RBS, coding sequence, and terminator) was used on the Registry documentation page (including relevant part numbers) to generate characterization data for basic parts.

For the most part, the process for judging basic and composite parts is identical. For basic parts, the focus is on conforming to Registry standards, since the ability to integrate into standard cloning systems is directly related to the parts' usefulness. For composite parts, the focus is more directly on usefulness, since composite parts can often function as standalone devices and do not necessarily need to be integrated with other parts.

Let's take a quick look at some examples of great composite parts:

Our first example is **BBa_K323135**: VioA and VioB enzymes fused with zinc fingers under pBAD promoter. This part was created by the **Slovenia 2010** iGEM team and won the award for Best New BioBrick Part or Device, Engineered.

Aside from being quite well documented, this part worked, was well-documented, and had a useful, novel function.

This part simply and effectively demonstrated how simple protein domains could be assembled into a higher-order organization using a DNA-guided mechanism to put functions of interest into the correct location and orientation for efficient bioprocessing.

This essential idea of DNA program-guided zinc fingers proved to be quite useful to the community (**aspect 4)**. Not only did it open up the field of engineered subcellular-level localization and spatially-sequential processing, but it was adopted by later iGEM teams, including **NCTU Formosa 2012**, who incorporated the exact design into their project to improve fermentation of isobutanol.

A second example is **BBa_K1150020**: uniCAS Activator (CMV promoter). This part was created by the **Freiburg 2013** iGEM team and won the award for Best New BioBrick Part/Device, Engineered in Europe.

Again, this part had excellent documentation, conformed to RFC10, and had data demonstrating its working function. Even though CRISPR/Cas had already been popularized within the biology/bioengineering community, the uniCAS project brought this powerful tool into the iGEM community and provided a standardized collection of parts (exemplified by this part) which will likely serve as the foundations for other teams who wish to use the CRISPR/Cas system. In fact, the collection has already made its appearance in this year's "Featured Collection" in the Registry.

Part Collection

The final parts award is the Best Part Collection. This award is given to the team that makes the best collection of parts that perform a useful or specific function for the community. A collection must contain at least 3 parts and there is no upper limit to the number of parts a team can submit. Only parts that teams have submitted can be eligible for this award, so anything that does not pass the part status check should be disregarded. The most important factor to consider when evaluating the part collection award is how the parts are related. Is it a real collection, or have the team just submitted 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).

Here are two amazing examples of Part Collections:

Freiburg 2012
Freiburg 2012 made a single pot TALEN DNA binding domain construction kit
Part Range: BBa_K747000 - K747102

Freiburg 2010
Freiburg 2010 made a therapeutic virus construction kit
Part range: BBa_K404001 - K404999

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 BBa_K747000 and BBa_K525710?**
3. **Did the team submit an internally complete collection allowing it to be used without any further manipulation or parts from outside the Registry?**
4. **Did the team finish building a functional system using this collection?**
5. **Did the team create excellent documentation to allow future use of this collection?**

Poster

Summary:

- Posters should be a ***visual*** summary of a team's project that should be presented by the team (at least one member) during a poster session.
- The poster should follow the poster guidelines and be appealing with nice visual flow.
- The poster session is the best opportunity for judges to talk with the team (ask questions, compliment good work, offer suggestions for improvements).
    - Teams love talking with judges, and judges often learn a lot of details at the poster session the would not have learned otherwise!

In iGEM, the purpose of the poster is to communicate the project to others in a very concise, yet engaging manner. In the past, posters have been too "busy" and "unbalanced" in regards to text, figures, and space. Therefore, updated poster guidelines were written to emphasize the importance of balance and visual appeal in this form of scientific communication (see below). There are five aspects for assessment that we should keep in mind as we evaluate posters:

1. **Did the poster flow well?**
2. **How professional is the graphic design in terms of layout and composition?**
3. **Did you find the poster appealing?**
4. **How competent were the team members at answering questions?**

The following details about poster format, poster components, poster evaluation criteria, and poster judging process are on the iGEM wiki (**see poster judging guidelines**).

Posters must conform to the following requirements (posters not conforming to these requirements will not be eligible for any special prizes):

- Maximum Dimensions = 4 ft. X 4 ft. (1.219 m X 1.219 m)
- Font size must be readable from a distance. Recommended font sizes are:
    - 44 pt for headers
    - 38-40 pt for body text
    - 18-24 pt for captions beneath figures
    - 18 pt for references/ acknowledgments

Judges will expect the following components to be present in some manner on team posters:

- Title
- Authors and their Affiliated Institution(s)
- Introduction
- Methodology
- Results/Conclusions
- References/acknowledgments
- Funding Attributions (If Applicable)

Past iGEM teams have also elected to include additional components on their posters such as:

- Abstract
- Objectives
- Motivation
- Team Achievements
- Future Directions
- Human Practices
- Parts Submitted

Judges should take a first pass at evaluating posters during free sessions while the team is not present. Judging during a free session allows you to ascertain if a poster can stand on its own as a clear communication of the project. *Presenters should not approach the judges during this time*. During the poster sessions, judges should visit the posters and discuss the projects with team members.

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. Evaluations of both the displayed poster and the oral presentation of the poster factor into the awarding of the Best Poster prize.

Teams should be cognizant of the fact that judges involved in the awarding of iGEM medals and other prizes may utilize the poster reception as a resource for making decisions on those awards.

In other words, all teams should strive to generate a high quality poster!

Let's look at two examples of winning posters. **Macquarie Australia 2013** won the Best Poster, Asia, Overgrad. Their poster has high visual appeal and shows a good balance of figures and text with appropriate use of white space . The poster is fairly easy to read with contrast between the text and background and an appropriate choice of background. Most of the figures/images on the poster are high quality (**aspect 2**).

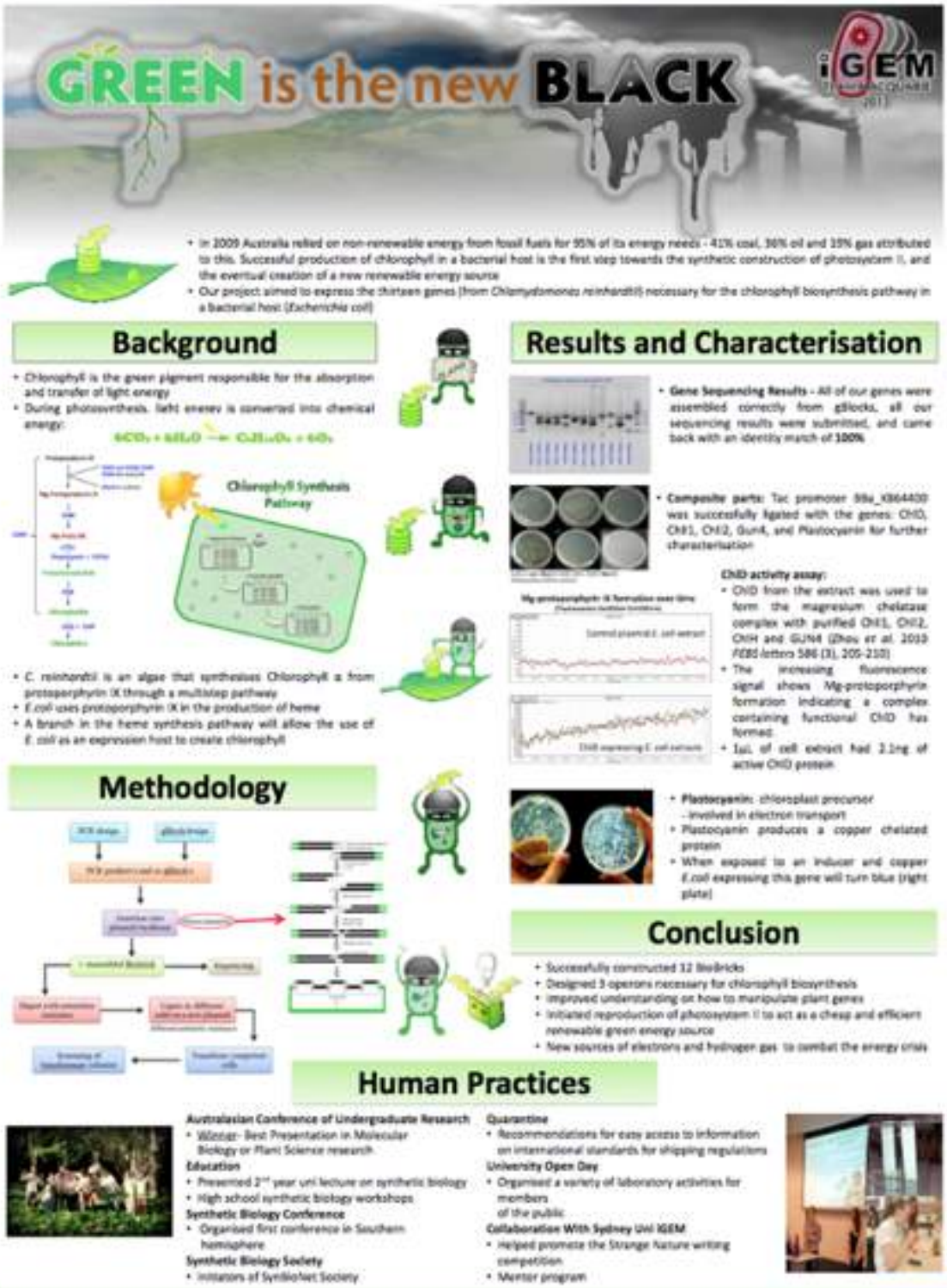
The resolution of the Gibson Assembly diagram could be improved as it is a bit fuzzy as presented here. The font used to label the axes on the activity assay figures should be enlarged so it's clearer (**aspect 3)**

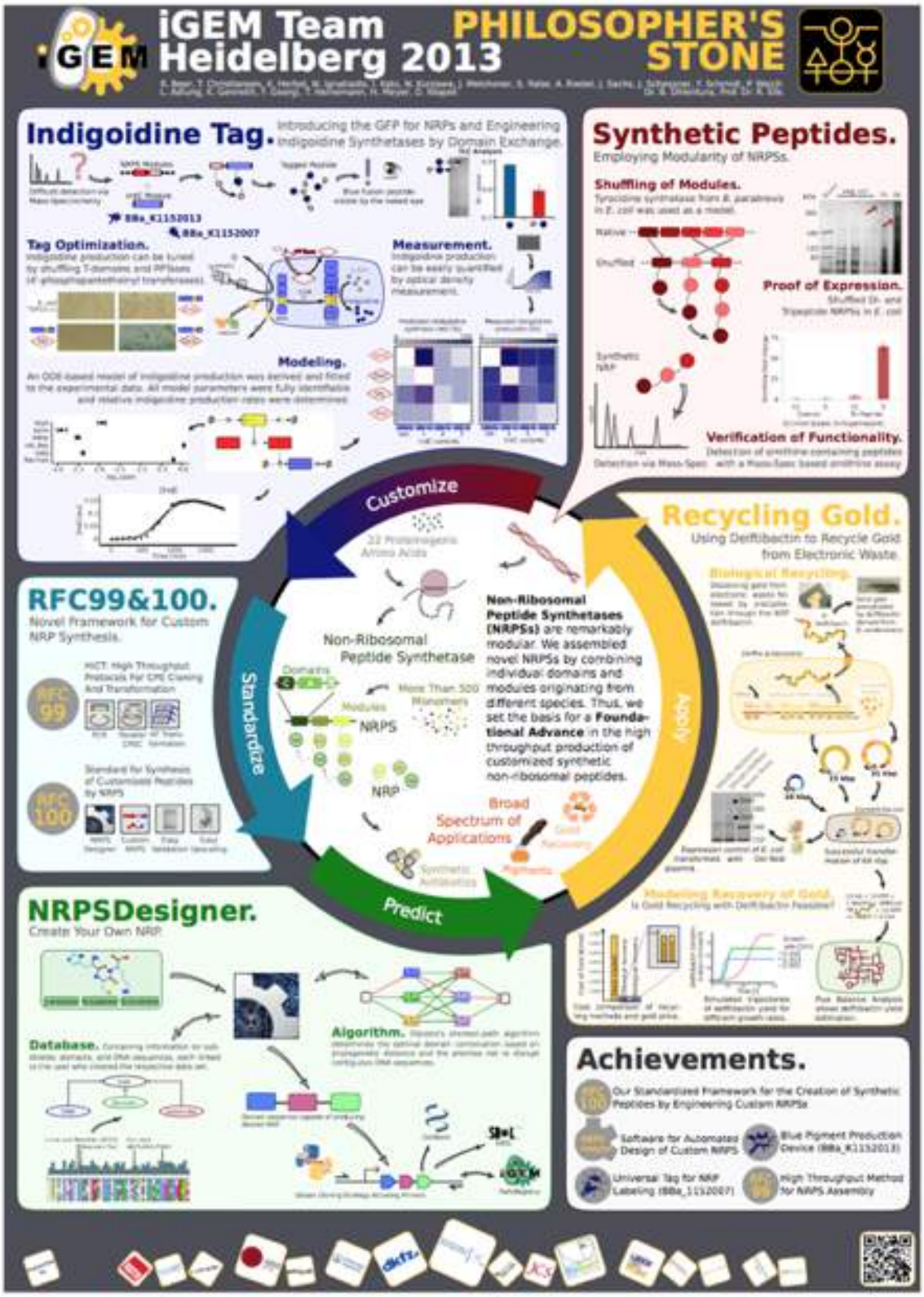
Additionally, the figure legends need additional information to make this poster "stand alone". Appropriate and relevant content was selected and the flow of the poster is logical and easy to follow. (**aspect 1**).

Judges have the following expectations of teams at the poster reception:

- Posters need to be set up for display by the deadline provided. Judges will be critiquing the posters before the poster reception commences.
- Some of the team members should be present throughout the poster receptions. Keep in mind that the team members have expertise in various components of the project. Inability of the team members who are present to correctly answer questions during the judges' visits could negatively impact the team.
- Teams should not select a single spokesperson for the team, nor should a single team member monopolize the oral presentation of the poster to the judges. Judges expect a "team" presentation of the poster, so make certain that team members who are present are prepared to contribute if called upon.
- Other members of the iGEM community may be visiting your poster when a judge arrives at the team poster. Teams should inform other visitors that they will have to return later because a judge is now present. Judges should be given priority during the poster reception because they have limited time to complete their judging responsibilities.
- Your oral presentation during the poster reception needs to be concise due to time constraints. If a judge requests a brief explanation, do not provide a lengthy one.

Heidelberg 2013 won Best Poster, Europe, Undergrad. This poster does a great job using color to guide the reader in navigating the poster—it's easy to tell which part of the poster goes with the summary in the center of the poster (**aspect 2**). Though the judges had some concerns about flow (**aspect 1**), there is a good balance of text and figures. The visuals components are high-quality and properly labeled.


GREEN is the new BLACK
iGEM
• In 2009 Australia relied on non-renewable energy from fossil fuels for 95% of its energy needs - 41% coal, 36% oil and 15% gas attributed to this. Successful production of chlorophyll in a bacterial host is the first step towards the synthetic construction of photosystem II, and the eventual creation of a new renewable energy source
• Our project aimed to express the thirteen genes (from Chlamydomonas reinhardtii) necessary for the chlorophyll biosynthesis pathway in a bacterial host (Escherichia coli)
Background
• Chlorophyll is the green pigment responsible for the absorption and transfer of light energy
• During photosynthesis, light energy is converted into chemical energy:
Chlorophyll Synthesis Pathway
• C. reinhardtii is an algae that synthesises Chlorophyll a from protoporphyrin IX through a multistep pathway
• E.coli uses protoporphyrin IX in the production of heme
• A branch in the heme synthesis pathway will allow the use of E. coli as an expression host to create chlorophyll
Methodology
Results and Characterisation
• Gene Sequencing Results - All of our genes were assembled correctly from gBlocks, all our sequencing results were submitted, and came back with an identity match of 100%
• Composite parts: Tac promoter 98a_K864400 was successfully ligated with the genes: ChlD, ChlI1, ChlI2, Gun4, and Plastocyanin for further characterisation
ChlD activity assay:
• ChlD from the extract was used to form the magnesium chelatase complex with purified ChlI1, ChlI2, ChlH and GUN4 (Zhou et al. 2013 FEBS letters 586 (3), 205-210)
• The increasing fluorescence signal shows Mg-protoporphyrin formation indicating a complex containing functional ChlD has formed.
• 1µL of cell extract had 2.1ng of active ChlD protein
• Plastocyanin: chloroplast precursor - involved in electron transport
• Plastocyanin produces a copper chelated protein
• When exposed to an inducer and copper E.coli expressing this gene will turn blue (right plate)
Conclusion
• Successfully constructed 12 bioBricks
• Designed 3 operons necessary for chlorophyll biosynthesis
• Improved understanding on how to manipulate plant genes
• Initiated reproduction of photosystem II to act as a cheap and efficient renewable green energy source
• New sources of electrons and hydrogen gas to combat the energy crisis
Human Practices
Australasian Conference of Undergraduate Research
• Winner- Best Presentation in Molecular Biology or Plant Science research
Education
• Presented 2nd year uni lecture on synthetic biology
• High school synthetic biology workshops
Synthetic Biology Conference
• Organised first conference in Southern hemisphere
Synthetic Biology Society
• Initiators of SynBioNet Society
Quarantine
• Recommendations for easy access to information on international standards for shipping regulations
University Open Day
• Organised a variety of laboratory activities for members of the public
Collaboration With Sydney Uni iGEM
• Helped promote the Strange Nature writing competition
• Mentor program
MACQUARIE UNIVERSITY
IDT


iGEM Team Heidelberg 2013
PHILOSOPHER'S STONE
Indigoidine Tag.
Introducing the GFP for NRPs and Engineering Indigoidine Synthetases by Domain Exchange.
BBa_K1152013
BBa_K1152007
Tag Optimization.
Measurement.
Modeling.
Synthetic Peptides.
Employing Modularity of NRPSs.
Shuffling of Modules.
Proof of Expression.
Verification of Functionality.
Customize
Standardize
Predict
Apply
Non-Ribosomal Peptide Synthetase
Non-Ribosomal Peptide Synthetases (NRPSs) are remarkably modular. We assembled novel NRPSs by combining individual domains and modules originating from different species. Thus, we set the basis for a Foundational Advance in the high throughput production of customized synthetic non-ribosomal peptides.
Broad Spectrum of Applications
RFC99&100.
Novel Framework for Custom NRP Synthesis.
Recycling Gold.
Using Deferibactin to Recycle Gold from Electronic Waste.
NRPSDesigner.
Create Your Own NRP.
Database.
Algorithm.
Achievements.
Our Standardized Framework for the Creation of Synthetic Peptides by Engineering Custom NRPSs
Software for Automated Design of Custom NRPS
Blue Pigment Production Device (BBa_K1152013)
Universal Tag for NRP Labeling (BBa_1152007)
High Throughput Method for NRPS Assembly

Presentation

Summary:

- The presentation is the chance for a team to tell their story in a concise and visually appealing way.
- Excellent presentations will be engaging, easily understood by a broad audience, balance big-picture ideas with design details, and flow smoothly.
- Teams should answer post-presentation questions competently and concisely; further detailed discussions can be held during poster sessions.

All iGEM teams must give a 20 minute presentation at the Jamboree about their project. 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 5 aspects for assessment in the iGEM rubric that we should keep in mind as we evaluate presentations:

1. **Did the presentation flow well?**
2. **How professional is the graphic design in terms of layout and composition?**
3. **Did you find the presentation engaging?**
4. **How competent were the team members at answering questions?**

Dundee 2013

To explore an example of an outstanding team presentation, let's take a look at **Dundee 2013**, the winner of the 2013 awards for Best Presentation, Europe, and Best Presentation, Undergrad (World Championship). First, you should definitely watch **Dundee's video** about targeting the toxin present in algal blooms.

Their presentation is truly engaging and literally "kept me on the edge of my seat!" (**aspect 3**). Rather than separate each part of the project and have a team member talk about just that part, they told a story, connecting the different parts of the project.

They began with an overview of their project and described how the public was included in the project from its start. Rather than sticking the human practices component at the end of their presentation, they weaved HP into their story and addressed issues and concerns throughout the presentation.

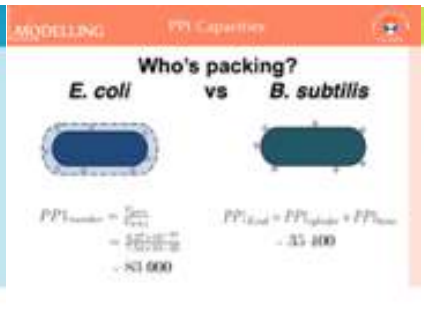
The presentation flowed (**aspect 1**) and led the audience to ask what's next. The three presenters made smooth and effortless transitions during the presentation. Speakers maintained eye contact with good voice quality. Their presentation style conveyed their excitement and enthusiasm for the project. Additionally, they introduced humor at timely and sometimes unexpected points during the presentation to keep the audience engaged (e.g., "How much wood can a woodchuck chuck…").

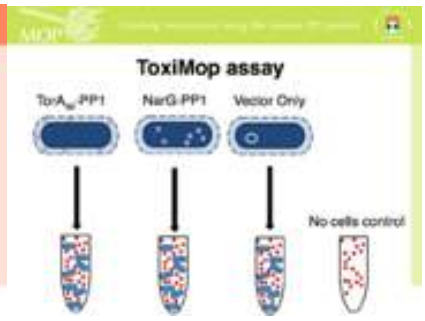
Also, it was clear that they practiced their talk, as their presentation was polished and professional. They even anticipated questions from the audience; they included extra slides at the end of their presentation, just in case (**aspect 5**).

Now let's focus on graphic design (**aspect 2**) – an impressive presentation would be error-free and need no verbal guidance. What can we say about the slides used in Dundee's presentation? One thing that immediately stands out is that the slides are really clean! What does that mean? The slides had high overall appeal and delivered a clear message.

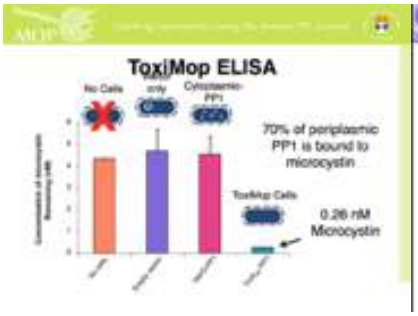
Here are some characteristics of those slides:

Good quality and choice of images



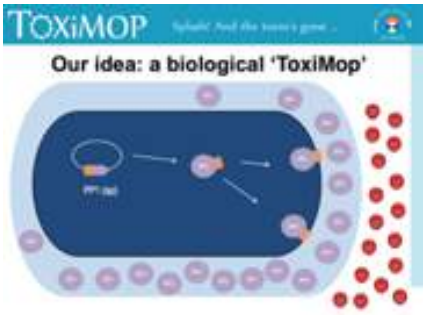


Emphasis on engaging visuals with minimal text



Slides are easily readable, with appropriate sizes for fonts and resolutions for images

Clearly labeled graphs with error bars



Meaningful animations (nothing too fancy or flashy)

Another characteristic of a good presentation concerns the use of color. It's important that the choice and use of colors are not distracting and contribute to the understanding. During the presentation, Dundee used colors effectively in the headers on the slides (see figure below). Each major part of their presentation had its own header to serve as a visual guide to the audience. Throughout the presentation, it was easy to see where the current slide fit into the overall project. This creative use of color with specific images and descriptive text greatly contributed to the clarity and flow in Dundee's presentation.

In summary, the Dundee 2013 presentation was recognized for its excellence in clarity (**aspect 1**), graphic design (**2**), and engagement of the audience (**3**).

Software Tool

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 also be user-friendly and have good documentation.

The software tool award is evaluated through the software tool section in the judging rubric. Teams must provide a 150 word description of what they accomplished in order to be evaluated. Judges should look at the software wiki pages and try to use the software if possible.

Teams can generate software that goes on github, so if you don't feel comfortable, please get in touch so that the Executive Judging 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. **Did the team use non-trivial algorithms or designs?**
4. **How easily can others embed this software in new workflows?**
5. **How user-friendly is the software?**

Valencia UPV 2016

Team's software tool judging form description:

"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 system 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.

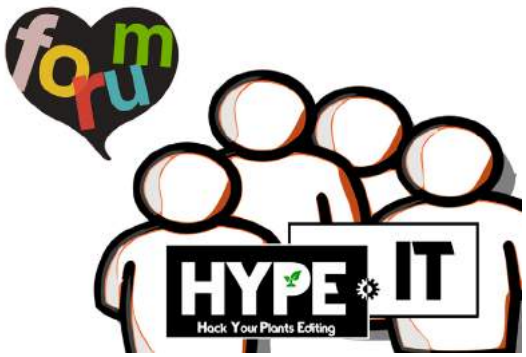
Like many software teams, Valencia have created an external website where judges and the public can access their work: **hypeit.cloudno.de/**

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.



The judges were impressed with the team's software, which was a well-executed component of a larger, well thought out and designed project. The Valencia team also scored highly in other areas of their project, showing that a strong, well integrated software component can have a beneficial effect on the project as a whole, providing it is presented as part of the overall story. Select judge comments:

"The software, hardware, and wetware are by themselves very impressive"

"The software, hardware, and wetware parts of the project BY THEMSELVES are among the best I've seen. Very impressive work on all efforts. I also loved the video on the home page of the wiki! Very easy to follow. I really, really liked the passion of the team and the central theme of the project: enabling anyone to do plant engineering."

HYPE-IT WORKFLOW

A farmer wants to improve his plant variety, thus he contacts with a plant breeder.

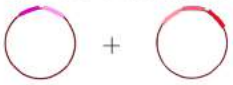
The plant breeder adquires **HYPE-IT Labware to improve his desired variety**

Check our open source database to find the optimal **g-RNA**

Order **g-RNA** synthesis

Luciferase gRNA Testing System

split-Cas9 in **viral system**



Higher efficiency in the **delivery** using viral vectors

Infiltrate plant leaf with **split Cas9** solution

Wait for very short time until the plant grows enough

Regenerate new plants from modified plant

Harvest seeds from regenerated plants

The farmer gets his plant variety modified without **split Cas9** in its cells

Supporting Entrepreneurship

Summary:
- The 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.

Entrepreneurship has always been a part of iGEM, even though there have not always been prizes to recognize the effort. From 2012 to 2014, iGEM hosted an entrepreneurship track which allowed teams to compete but with their main focus being on business ideas instead of synthetic biology. Starting in 2015, achievements in entrepreneurship were recognized with a special prize instead of a track.

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

1. **Customer Discovery - Has the team interviewed a representative number of potential customers for the technology and clearly communicated what they learned?**
2. **Based on their interviews, does the team have a clear hypothesis describing their customers' needs?**
3. **Does the team present a convincing case that their product meets the customers' needs?**
4. **Has the team demonstrated a minimum viable product (MVP) and had customers to commit (LOI, etc.) to purchasing it / using it?**
5. **Does the team have a viable and understood business model/value proposition to take their company to market?**

The focus of the 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.

To explore entrepreneurship in iGEM through a customer-focused case study, we will look at **Benchling.**

MIT 2012 E

In the first year of the entrepreneurship competition, the MIT team chose to build software to make editing, analyzing and sharing DNA sequences much easier. They ran their software on several Amazon web servers which continue to operate as they have built their business: **https://benchling.com/**.

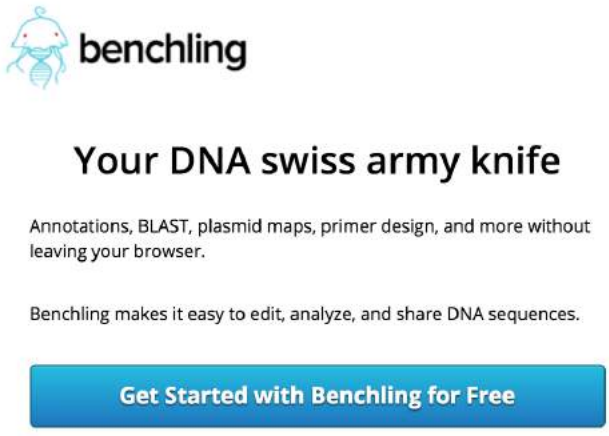
Although the judging criteria by which Benchling were evaluated have changed since 2012, the project that resulted from their efforts is still the type of project we are looking for today. We will retrospectively apply today's judging criteria to their project to show how they performed and illustrate the type of projects we are seeking.

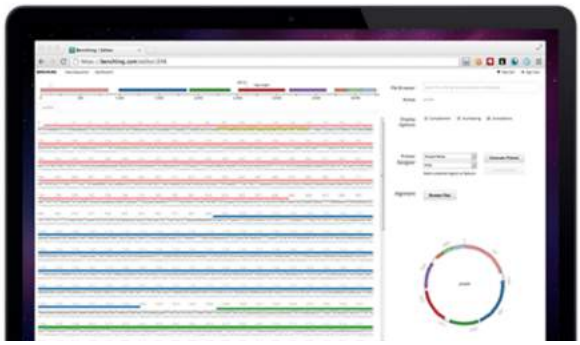
Benchling set out to make DNA editing software that was better than everything else on the market. At the time, their competitors were programs such as Vector NTI, a plasmid editor (APE), and online web-based tools such as Synbiota. Realistically, however, many scientists were still using non-specialized programs like Word or Excel to manage DNA design.

Benchling needed to offer something that was cheap/free, user-friendly, reliable to avoid loss of data, and used version control. The tool they built did all of these things.

Benchling had their product in the hands of researchers at Harvard, MIT, UC Berkeley, UCSF and UC Santa Cruz before the wiki freeze. Altogether, these institutions likely had many, many users in total, allowing Benchling to get feedback quickly.

As their product was entirely accessed online, they could iterate versions and incorporate requested changes as fast as they could code (**aspect 1**). At the time, the DNA analysis software on the market was either expensive, had a poor user interface, was not reliable, did not do version control, or possessed a combination of these issues. Benchling set out to make the best product on the market by addressing these issues with their minimum viable product (**aspect 2**).



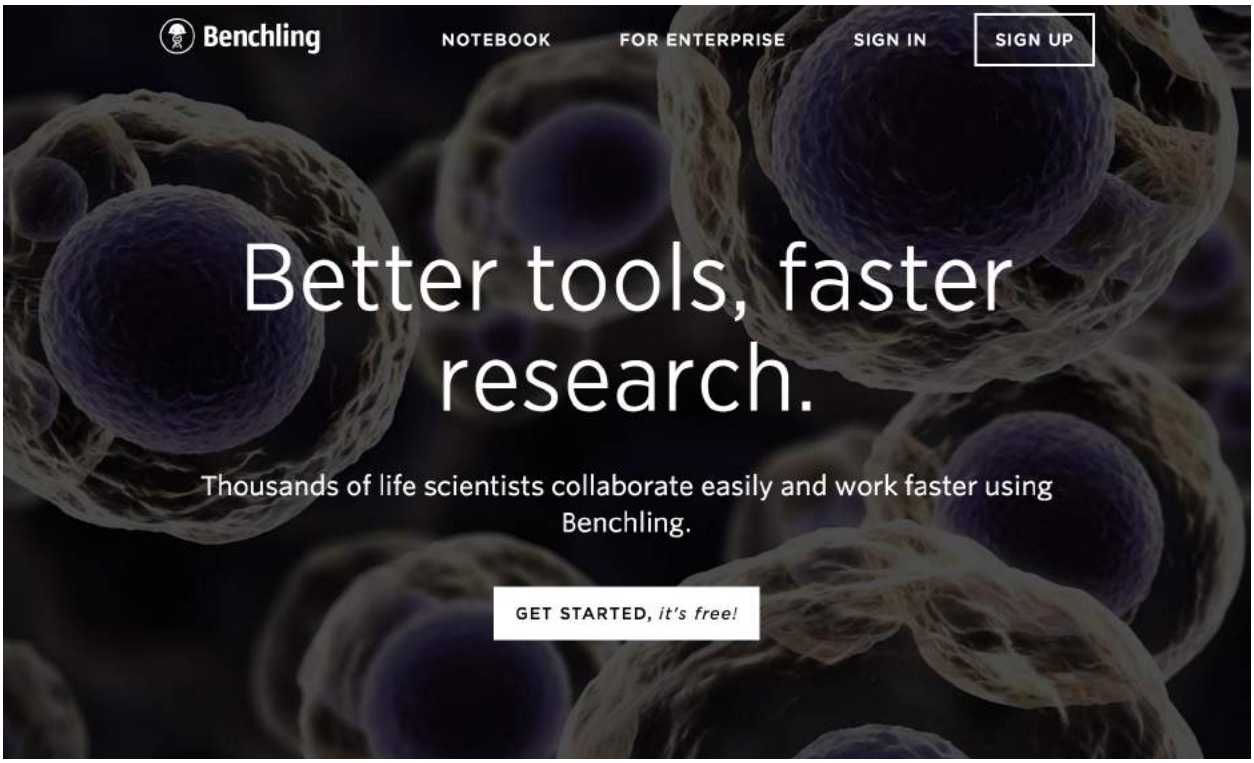


From the 2012 Benchling wiki (**aspect 3**): "Benchling is a platform for life science data management. It allows scientists to edit, analyze, and share DNA sequence data. Scientists build with DNA, just like programmers do with code. Major biotech companies account for 2% of the US GDP. Despite this value, there is no version control in life science. These companies have no cloud-based tools for facilitating collaboration and sharing between their scientists."

The online demo of the Benchling MVP was successful enough to gain early adoption in at least 5 major research-focused institutions before the 2012 wiki freeze. Not only did Benchling build an MVP, but they were actively working with users to develop their product during the competition. While this model currently applies much better to software than synbio, the field is advancing rapidly and development cycles relying on DNA synthesis assembly are constantly shrinking.

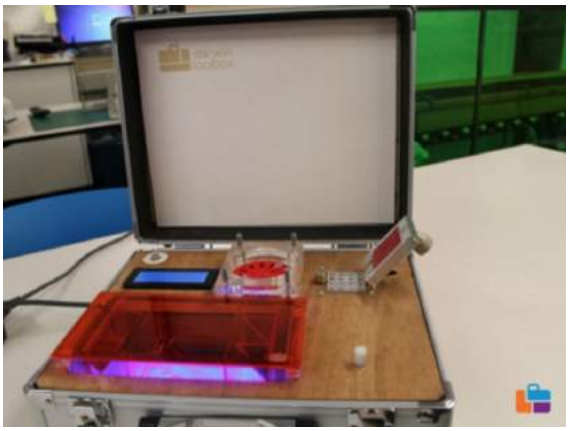
It was not clear from the Benchling wiki if they had paying customers in their user base (aspect 4). Benchling initially set out to make their tool free to use for students but with a pay subscription model for faculty, labs and industry. Their strategy was successful as by fall 2013, they had thousands of customers in many academic institutions all over the world. Again, the freemium model is common in software development, but has yet to gain traction in the synbio industry (aspect 5).

Benchling are still in operation as of May 2016. After the 2012 entrepreneurship Jamboree, they relocated to San Francisco and **in April 2015 received a $5M investment from Andreessen Horowitz**.



UCL 2013 E

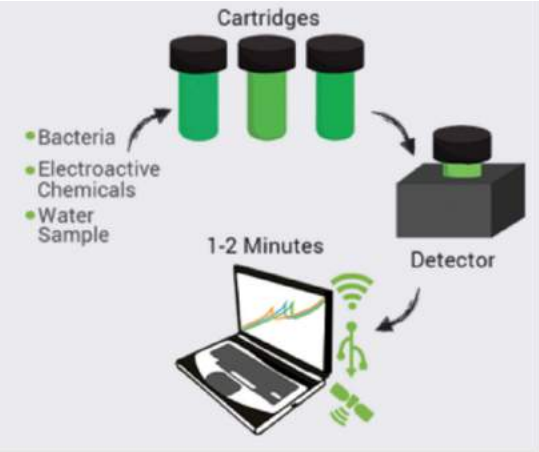
Another excellent example is the Darwin Toolbox, a hardware project presented by the **2013 University College London iGEM entrepreneurship team**. They wanted to address lack of widely available synbio tools by making a cheap, safe, user-friendly lab-in-a-box for high schools and community labs



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 of if they had any committed customers. After coming across some trademark issues, Darwin Toolbox rebranded as **Bento Bio** and have continued to work on their project. In 2015, the project was successfully funded on Kickstarter to launch mass production.

Calgary Entrepreneurial 2013

FREDsense was the **2013 Calgary Entrepreneurship** 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. They are the only team among these examples to use their biological product in a commercialization environment.



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.

Entrepreneurship in iGEM entered a new phase in 2015. The track was replaced with an award, allowing any iGEM team to consider how to build a company and get feedback on their project.

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.

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 and researchers 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 his or her 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. In the current rubric, there are five aspects for wiki assessment that we should keep in mind as we explore the team's wiki.

1. **Do I understand what the team accomplished?**
2. **Is the wiki attractive and easy to navigate?**
3. **Does the team provide convincing evidence to support their conclusions?**
4. **How well does the team describe what they did and what was done by others?**
5. **Will the wiki be a compelling record of the team's project for future teams?**

SDU-Denmark 2014

Looking at the front page for the SDU-Denmark wiki (shown below), we can see that the color scheme and layout is visually appealing (aspect 2). 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 in the next page.

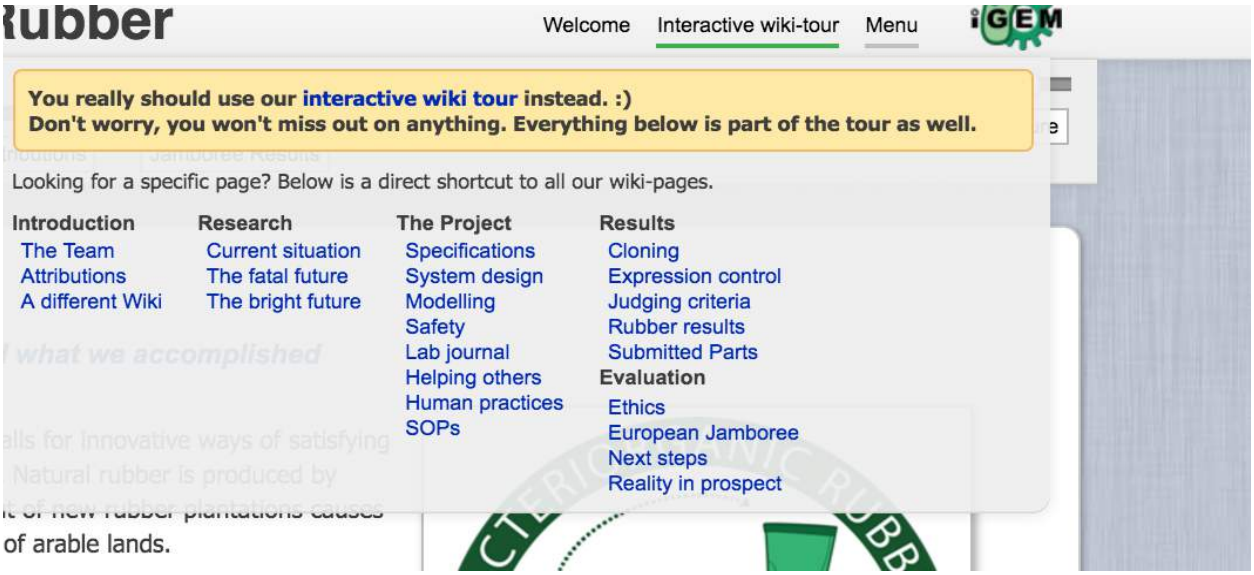
Following standard scientific writing, the team has begun their story with a summarized “abstract” of their project (**aspect 1**). At the top of the page, we can also clearly see a navigation track (**aspect 2**):

From the very beginning of their tour, SDU-Denmark has made it very easy for a judge to find the answers to **aspects 3 and 4** regarding data and attributions (see the red arrows). However, for a viewer less interested in these Jamboree-specific questions, one can simply skip to the next chapter (“Rubber Issue”) that deals more with the story behind their project.

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 (**aspect 2**) 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) (**aspect 4**).

The information is laid out in a way that is visually easy to read and uses language that is easy to understand (**aspects 1 and 2**). 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 (**aspect 3**).



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 (**aspect 5**).

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 exemplar in every way.

From the above, we can see why this wiki earned high marks in all four 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 four aspects for wiki assessment, they can be very useful to a judge before, during, and after a team's presentation when he or she is 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.

Rubber results

Did we indeed make rubber?

Now that we control the expression of the genes it is time to characterize our central genes *(dxs (B. subtilis)* and *HRT2)*. We invite you along on a journey through our attempts to obtain proof of concept; to show that Bacteriorganic Rubber is a true possibility.

Characterization of dxs *(B. subtilis)*

Functionality assay

To optimize the flow through the MEP pathway, the dxs gene was overexpressed, the expectation being increased levels of IPP and DMAPP (see Specification). To examine if overexpression indeed resultats in an increase in substrate, we attempted to assay the levels of DMAPP using a headspace gas chromatography (GC)-technique.

DMAPP was hydrolyzed in acid to the volatile hydrocarbon gas isoprene. The gas was subsequently analyzed with headspace GC. A linear relationship between amount of detected isoprene and DMAPP concentration has previously been established. We were capable of producing a standard curve by reacting DMAPP with acid for 2 min (instead of the 60 min specified in the previous study) **(Fig. 1)**. At this time, we obtained optimal peak detection for standard solutions. We were, however, incapable of detecting isoprene, even in high concentrations of bacterial samples treated with acid. The test was expanded to include acid hydrolyzation for 2, 30, 60 or 90 min, yet we could not detect isoprene, and therefore not detect DMAPP.

Optimization of the procedure is needed before characterization of the dxs bricks can be completed using this approach. We suspect that the complexity of the bacterial samples is too high, and thus the reaction does not take place as fast as might be necessary for detection in our setup. Sonication of bacterial samples with and without addition of standard DMAPP, and subsequent measurements might shed some light on this hypothesis. However, it should be noted that the GC wasn't fully functional during the test period, consequently leading to broader peaks and thus lowered the sensitivity of the instrument. On the 3rd of October, we received a mail from Professor Lars Porskjær Christensen, Department of Chemistry-, Bio- and Environmental Technology, University of Southern Denmark:

"...The GC has now been repaired and the sensitivity has been improved considerably. The GC-peaks should be very sharp now. This may be the reason that you have not observed any release of isoprene from your samples...".

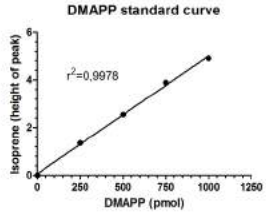


Figure 1.

SPECIAL TRACKS

Special Tracks

Special tracks in iGEM are how students and members of the community participate in iGEM in areas that do not necessarily require submission of BioBricks. We evaluate these teams differently, without the need to award them medals based on parts. Thus, we can be inclusive of all types of teams from different schools.

These teams are will also have exhibition space at the Giant Jamboree. The intention is to enable teams to bring e.g artwork, giant robots, measurement devices and software demos to the Jamboree and show them off to our community. Because of this advantage, special track teams will not be competing for the Grand Prize.

There are four special tracks in iGEM in 2017:
Art & Design
Hardware
Measurement
Software

None of these tracks are evaluated on their parts. They can still make parts if they choose, but there is no specific mention of parts in the medal criteria for teams in these tracks.

The most significant difference between standard iGEM tracks and special tracks are the medal criteria. To manage the complexity of evaluation in iGEM, eight sets of medal criteria were merged into only two in 2017. Please visit **2017 iGEM Medals** for the medal requirements for the special tracks. Additionally, special tracks are not split into undergraduate and overgraduate sections.

In 2014, track-specific evaluation aspects were introduced to help assess standard vs. special track teams. These aspects reflect the changing nature of the competition and that not all teams are required to construct DNA parts. In the 2016 rubric, special track teams are evaluated using the eight aspects (see the Excellence in iGEM section) representing the key iGEM values that apply to all teams, irrespective of track, and the following two track-specific aspects for Special Tracks:

1. **Did the team design a project based on synthetic biology?**
2. **Are the project components (hardware, software, art & design, etc.) thoroughly documented on their wiki?**

Art & Design

- Art & Design projects do not make parts, but instead create a project that asks questions, addresses implications, or applies synthetic biology for a novel purpose (e.g., fashion).
- Excellent projects will vary widely in content and purpose, but they often tie together the human experience with synthetic biology in a new and creative way.
- A&D teams should present their work in the A&D installation space.

At first glance, Art & Design seems to sit apart from tracks at iGEM that focus on scientific or technical challenges. But when you take a deeper look, you'll find that the best iGEM projects depend heavily on art and design. How so? Look at the past winners of the overall competition.

You'll be hard-pressed to find teams that didn't 1) convey their concepts with aesthetically compelling narratives, 2) elaborate novel ways that synthetic biology could reshape our made world, and, by doing so, 3) investigate our current individual, social, and technological conditions and 4) imagine how they could be different.

Good art and design performs all of these intrinsically, but there is one major caveat that differentiates this track from others. Most iGEM projects aim to use biology to solve clear, finite problems in the world. This goal is not always the case with art and design. Art and design teams can use synthetic biology to reveal new problems in the world and to sometimes reflexively reveal problems with the aspirations of synthetic biology itself. These projects ask the difficult question of "Why?" Why do we think the way we do? And why can't it be otherwise? These projects are important because they ask us to rethink what we're doing.

Below, you'll find art and design case studies from previous iGEM projects. For simplicity's sake, we've categorized art and design under two different subheadings, "Art" and "Design." This organization should not mislead you into decoupling them.

People often distinguish design as focusing on a particular "application." A rubber eraser, for example, provides an elegant way to remove pencil marks. In contrast, they distinguish "art" as focusing on a particular set of "implications."

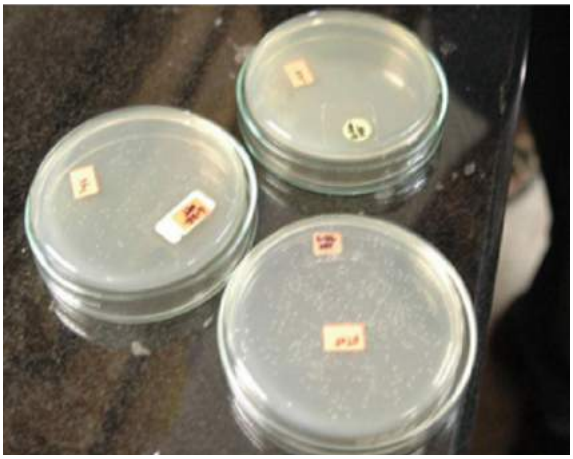
The giant sculpture of an eraser outside the National Gallery in Washington, D.C., says something about the ubiquity of office rituals in our lives (Claes Oldenburg and Coosje van Bruggen, 1999). In reality, the boundary between art and design is often not so clear cut.

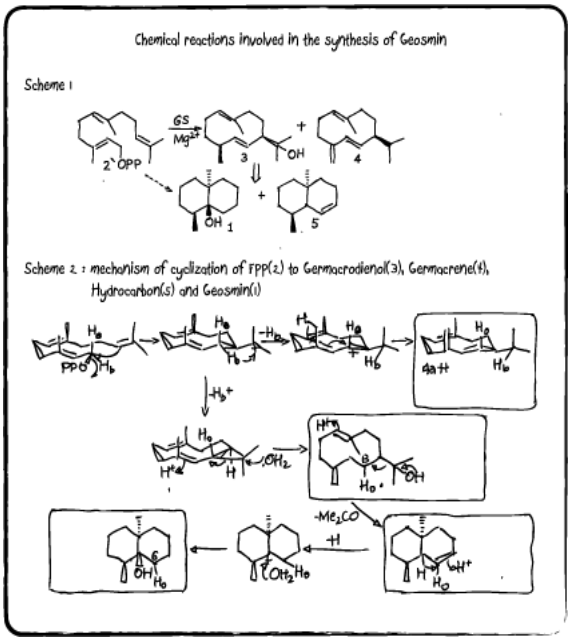
Art Science Bangalore 2009

Art Science Bangalore set out to biosynthesize the chemical geosmin in E. coli. Literally meaning “earth odor,” the microbial metabolite is responsible for the characteristic smell of moist soil or freshly plowed earth. Geosmin is produced by a number of soil bacteria and fungi.

The team’s goal was to recreate the smell of Indian earth after a heavy rainfall. The project was a poetic statement and a way of investigating the emotional and human sides of using synthetic biology.

This area is often disregarded by scientists seeking to purely advance the science, but is something vital to the future of synthetic biology if it is to someday become truly integrated within society. This project was simple and subtle, allowing people to connect to biology on a nostalgic and personal level and providing an essential experience for people who interact with this work. We shouldn’t only think about synthetic biology cognitively, but also sensually and emotionally.

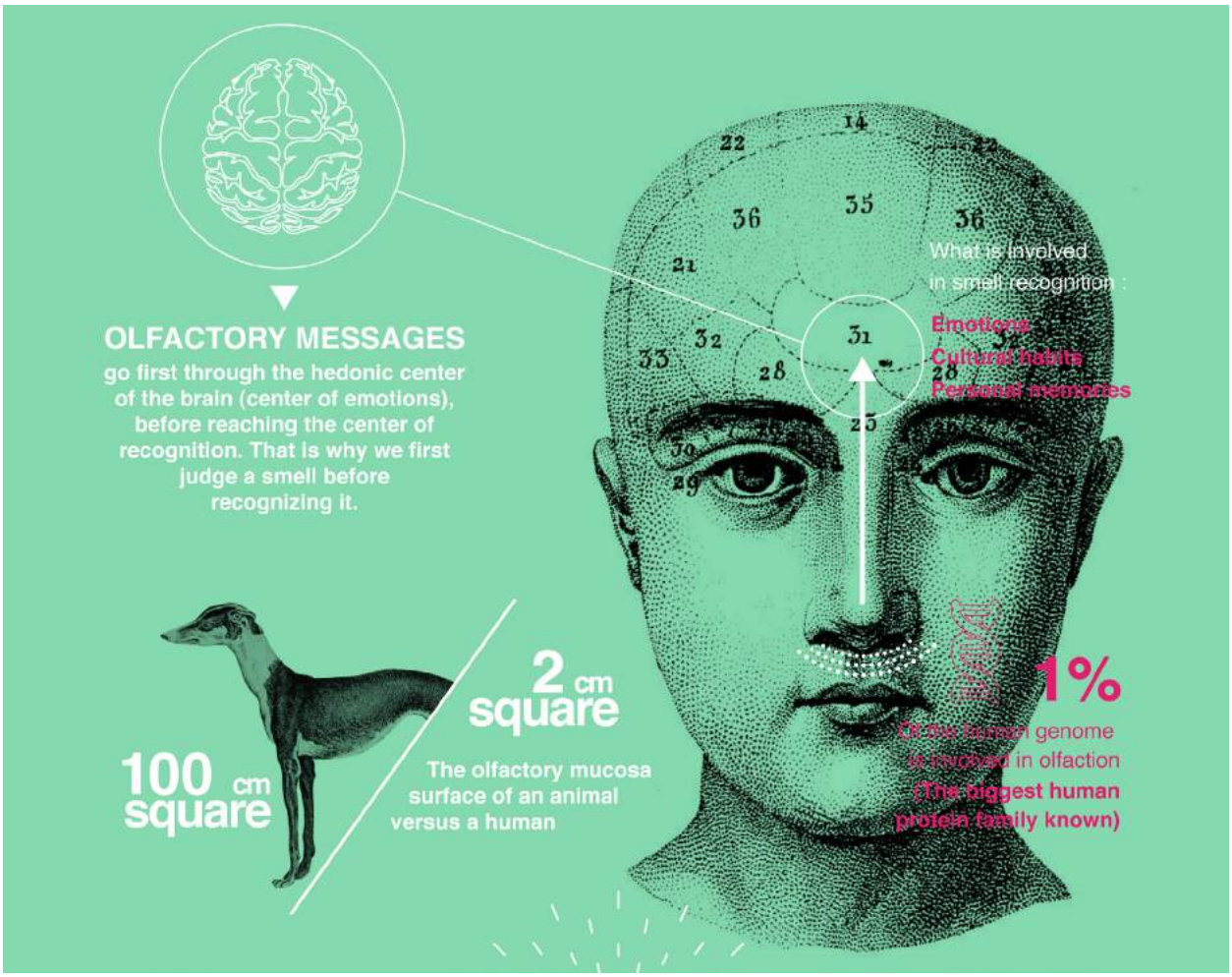




Paris Bettencourt 2014

Five years later, Paris Bettencourt 2014 took up where Bangalore left off, adding a number of scents to the iGEM registry such as popcorn and jasmine. Although not an art project per se, the project did investigate the meeting of synthetic biology and aesthetics. The team explored scents related to the human body and ways synthetic biology might mitigate them by altering the human microbiome with bioengineered microbes.

Through a participatory smell game that involved participants from around the world, the project took a deep dive into the sense of smells and the ways we react and relate to them emotionally. The team did excellent work in creating a narrative around its project while exploring how synthetic biology might reshape our sensorial experiences (**track-specific aspect 1**).



Art Center MDP 2014

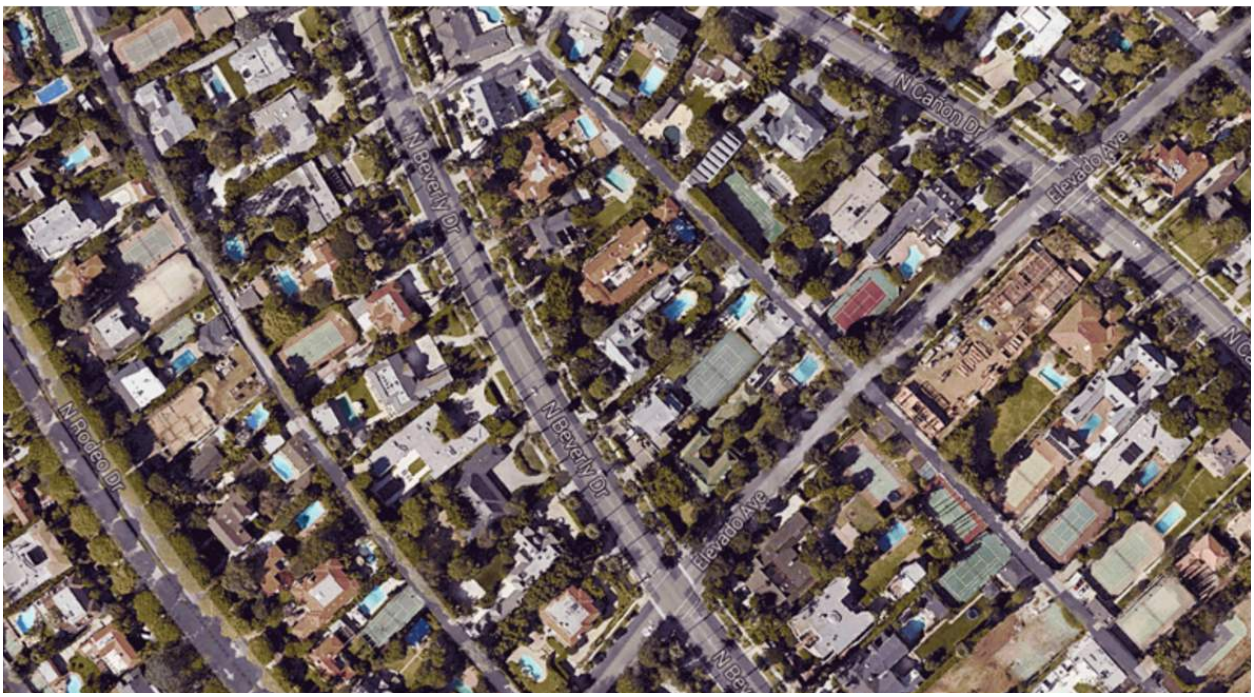
The winner of the 2014 Art & Design Track, the Art Center MDP team created “Car Pools,” a project that imagined converting Los Angeles’s swimming pools into a network of open ponds for biofuel producing algae. The project was a critique of current metropolitan sustainability practices: Los Angeles has a water problem. It depends on water piped from Northern California yet has 43,000 swimming pools, many of which are rarely used. At the same time, the city is famously dependent on cars and fossil fuels for transportation.

The project addressed both dependencies in one fell swoop with the improbable but clever solution of turning swimming pools into open ponds for algal fuel production.

The power in this project is that it delved into the senselessness of the city’s current geopolitics and asks why can’t this be different.

The seemingly absurd solution the team posed may in fact be more logical than the city’s current situation. The team went even further by taking its premise seriously through a series of experiments and demonstrations that explore the feasibility of its idea. At the same time, juxtaposing LA’s current situation with its speculative parallel, the project asked the viewers which scenario is more desirable, if either.

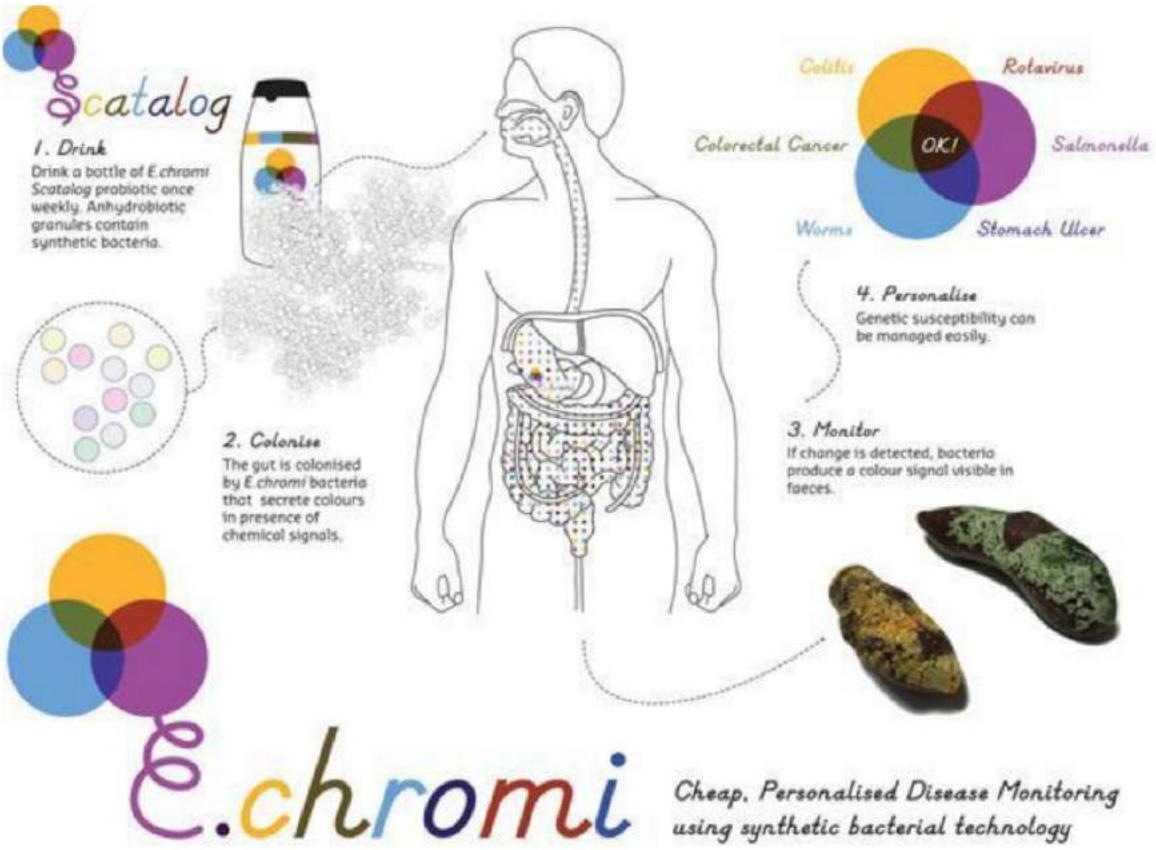
Car Pools asked how synthetic biology might be “domesticated” literally in our homes (track-specific **aspect 1**). The team imagined new social practices that might emerge from having your pool filled with algae. They experimented with “simulations” using non-engineered algae in baby pools in their yards throughout the summer, where they learned how to care for this living creature in their backyards.



Cambridge 2009

Cambridge did a fabulous job before art and design was a track with its “E. chromi” project in 2009. Having won the grand prize that year, the team demonstrated the effectiveness of art and design at iGEM. The team worked on a series of inducible promoters and a rainbow of pigment genes for the production of bacterial biosensors that change color under different conditions.

In conjunction with a team of artists and designers, the team brainstormed a number of future scenarios (many funny) that integrate color and synthetic biology. The affiliated artists, Daisy Ginsberg and James King, created a video highlighting the project. Student videos should strive to achieve similar results. Both fun and creative, the video demonstrated how the team had considered how their technology might be applied in the future—beyond just the obviously beneficial uses: **https://vimeo.com/19759432**



Hardware

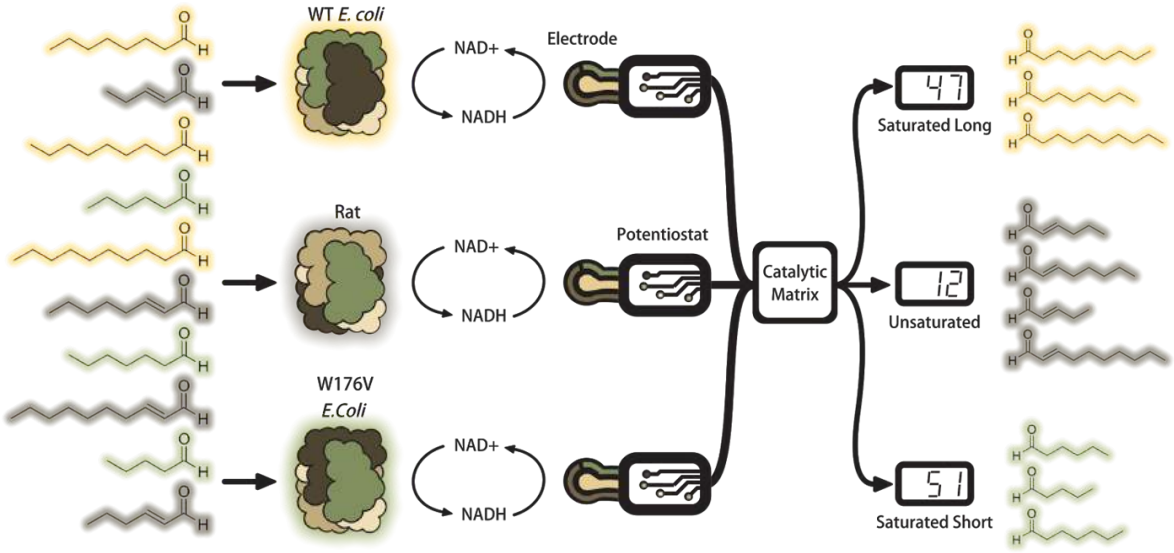
- In lieu of making parts, Hardware teams will construct a prototype device that performs some task in synthetic biology.
- Excellent projects will effectively perform their intended task. They will also be novel, useful, and well documented.
- Hardware teams are encouraged to present their device in the Hardware installation space at the Giant Jamboree.

For a successful hardware project, the team will 1) demonstrate utility and functionality in their hardware prototype and 2) document the hardware system (design files, bill of materials, assembly instructions and/or software) sufficiently to enable reproduction by other teams. Let's look at two teams who accomplished these criteria in 2014.

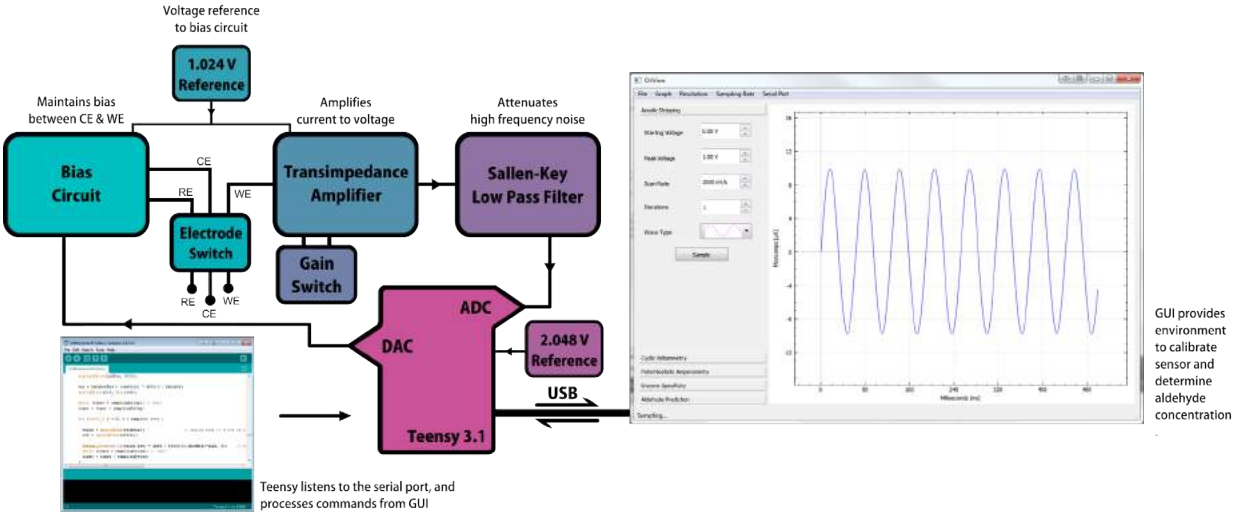
UC Davis 2014

UC Davis won the 2014 overgraduate division grand prize for their "OliView" project, which sought to achieve rapid and inexpensive quality control for olive oil. The motivation for the project was laid out clearly: over 65% of olive oil sold in the US is rancid, and there's no fast and reliable way to ascertain the quality.

To meet this need, the UC Davis team integrated protein engineering, hardware design, software, and human practices to create an inexpensive platform for measuring olive oil quality. While the hardware track did not exist in 2014, the OliView hardware component meets several of the rubric criteria for the 2015 hardware track.

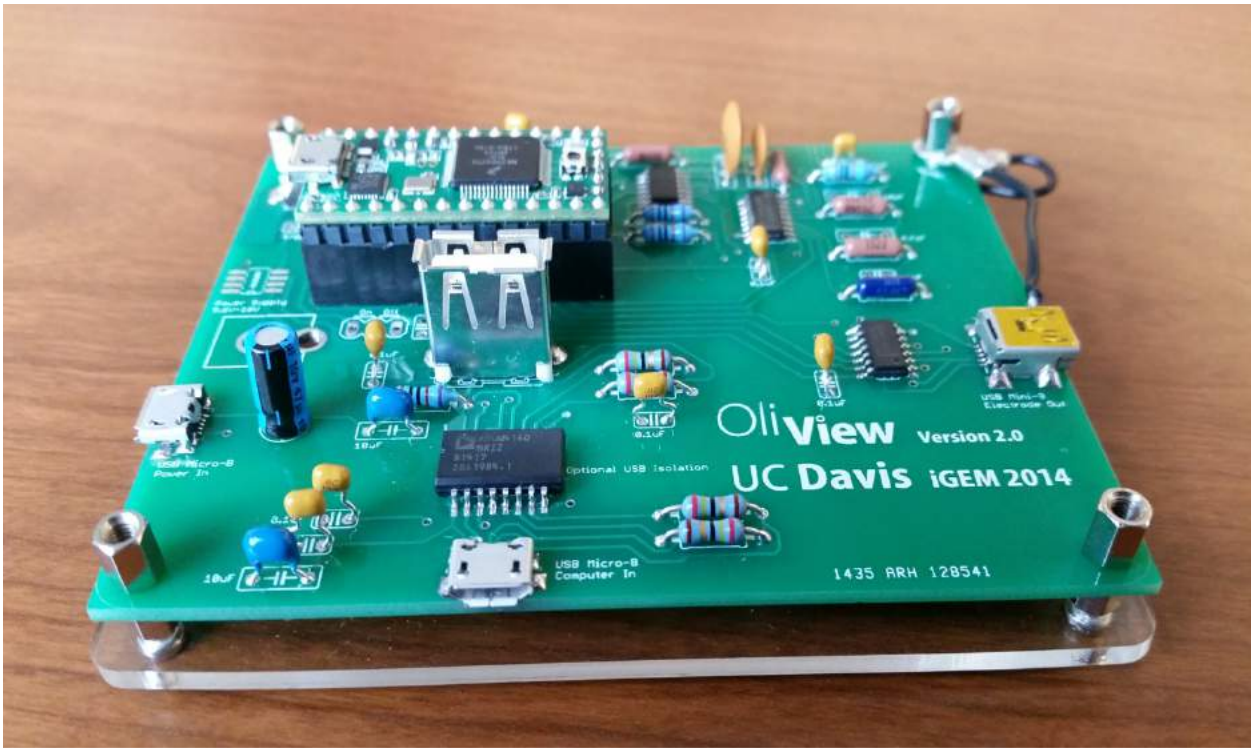


Fresh and rancid olive oils differ in their concentrations of unsaturated, medium saturated, and long saturated aldehydes. The team engineered several aldehyde dehydrogenase enzymes with varying aldehyde specificities, which generate NADH at different rates depending on the substrate present. In this way, when their engineered enzymes are added to olive oil extract, a unique electrochemical signal is produced dependent on the oil quality. To measure NADH production, the team built and tested a potentiostat—a device that keeps the voltage between two electrodes constant.



When NADH is made, the potentiostat oxidizes it to NAD+ at the electrode and generates measured current. Potentiostats are widely used to study redox chemistry, but the team found that existing commercial options didn't suit their needs, and therefore they built their own. Key to the potentiostat's function was the selection of appropriate electrodes. Considerations included sensitivity, selectivity, affordability, and portability. They ultimately decided upon an inexpensive pre-manufactured electrode.

Schematics and PCB design files, a bill of materials, and software were each supplied on the team wiki (track-specific **aspect 2**). The team was honest about their inspiration for their potentiostat, the CheapStat from UC Santa Barbara. The CheapStat was controlled using machine level code which the team decided would be unreasonable to learn given the project's time constraints. However, they ended up modeling their circuit on the CheapStat.



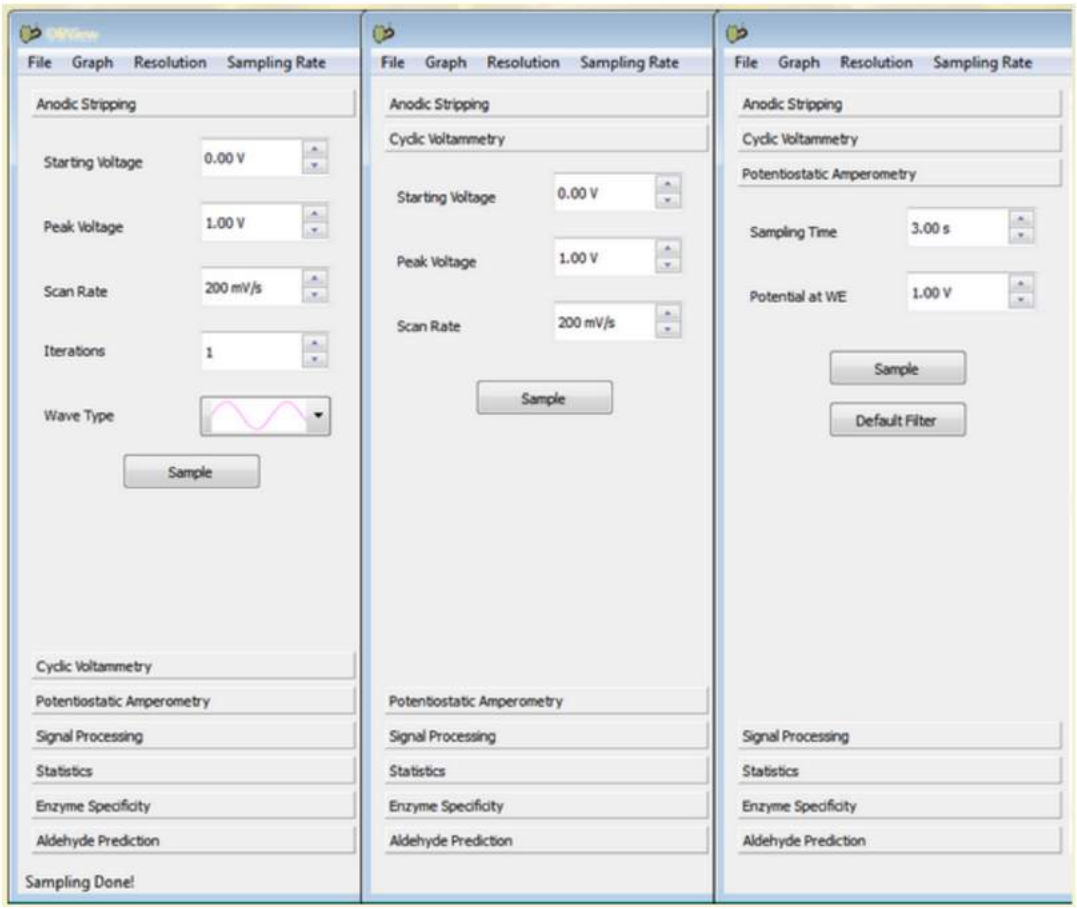
The OliView potentiostat took shape over multiple rounds of revision, from a breadboard prototype, to a circuit board made using a milling machine on campus, to a printed circuit board (PCB) designed using CAD software and sent to a PCB manufacturing company. At each step, the improvements and lessons learned were concisely reported for each version. In addition, the team offered instructions on the wiki for building your own OliView (track-specific **aspect 2**). A video tutorial for using or building the device would have made an excellent addition.

The OliView software component was also well documented, with descriptions of the microcontroller backend and different electrochemical operations available to the user, and explanations for the signal processing and statistics. Further, their software was made available at GitHub.

Finally, the UC Davis team integrated policy and practices into the motivation and design of their project (all teams **aspect 7**). T

hey specifically sought to answer the question, "What sector(s) of the olive oil industry would benefit from the [OliView] device and be likely to utilize it in a commercial setting?" They met with olive oil producers, research scientists, and stakeholders in the olive oil industry and then summarized their findings in a report. They found that their low-cost biosensor could help maintain olive oil quality standards in the state of California, and could aid in the creation of a state seal for olive oil quality.

Overall, the UC Davis team's execution of their project was outstanding in several aspects. The protein engineering, device implementation, and software design were all documented in clear, concise detail with schematics, code, and instructions at each step. Their project had a clear goal that was guided by discussions with many people in the olive oil sector. It seems possible that the OliView platform might make a real impact for olive oil quality.



Aachen 2014

The Aachen 2014 team won a gold medal and best Measurement Project at the 2014 Jamboree. Aachen 2014 exemplifies the spirit of iGEM's hardware track goals with it's combination of synthetic constructs and measurement hardware to create a novel biosensor capable of detecting pathogens.

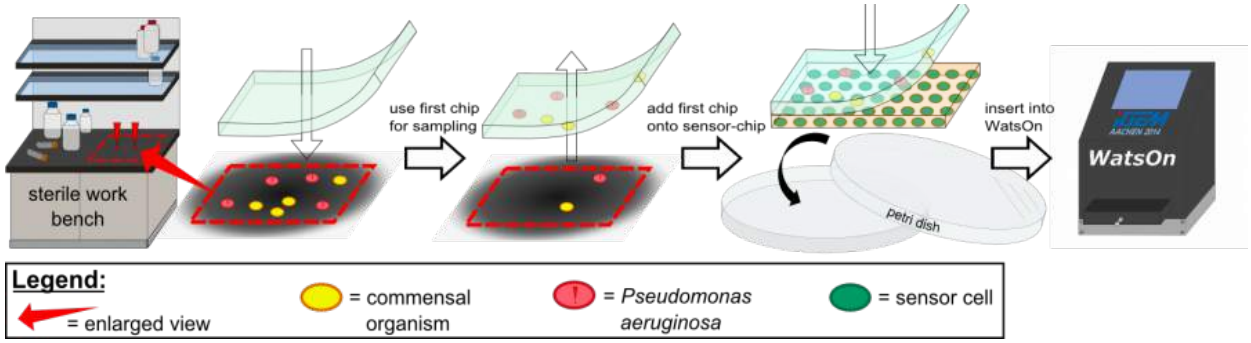


Figure 1: Assay to detect P. aeruginosa using Cellock Holmes. This flow sheet shows the procedure to sample and detect P. aeruginosa: A sampling chip is briefly put onto the potentially contaminated surface, added onto one of our sensor chips and inserted into WatsOn.

The system works by collecting cells from a hard surface onto an agar pad. The agar pad is then transferred to a sensor chip that has been coated with E. coli that are sensitive to the quorum sensing molecules secreted by specific pathogens. A researcher then places the assembled chip and agar pad into their hardware measurement device named WatsOn (Fig. 1).

Once the chip (LB agar mixed with sensor cells) has been loaded into the WatsOn, the chip is incubated allowing both the sensor cells and pathogens to grow. In the presence of pathogenic cells, a quorum will be reached and the sensor cells will fluorese. The fluorescence can be detected by the fluorescence camera in WatsOn (Fig. 2) and a classification algorithm can determine the presence of absence of pathogens.

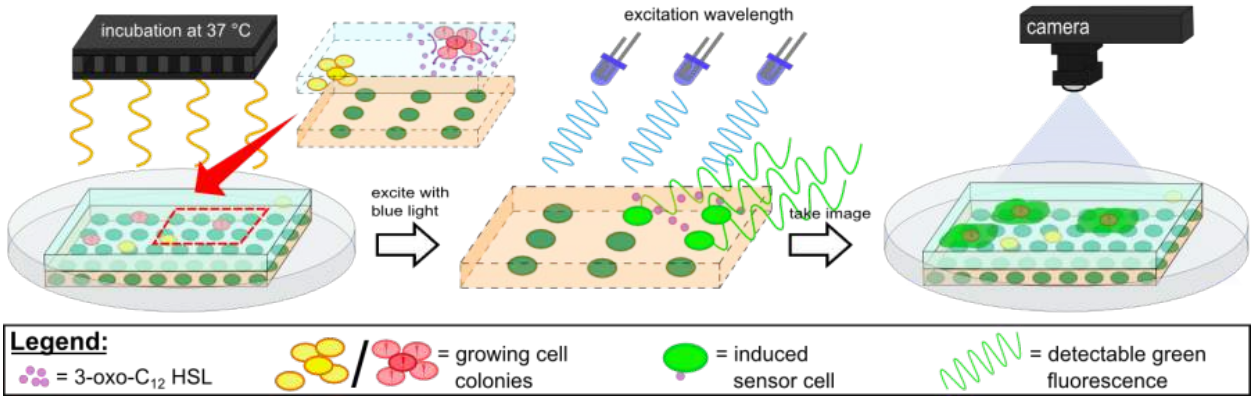


Figure 2: Mode of action inside WatsOn. Chips are incubated at 37°C to stimulate cell growth and then illuminated with blue light to excite fluorescence. A picture is taken and analyzed for fluorescence signals using the software Measurarty.

A basic judging criteria required for all medals in this track is that the team demonstrates a working prototype. In Aachen 2014's case they did an excellent job. Aachen's website gives a complete characterization of WatsOn demonstrating its functionality detecting IPTG, 3-oxo-C12-HSL, and living Pseudomonas aeruginosa, a human pathogen (track-specific **aspect 1**).

Reproducibility and, in the case of hardware, open design are important characteristics of every successful iGEM project. Aachen 2014's website has an excellent guide that contains all software, source code, a complete bill of materials, and assembly and operating instructions. Their website enables any researcher to assemble and operate their own instantiation of the hardware. (track-specific **aspect 2**).

Aachen 2014 addressed "beyond the bench" issues in multiple ways. They developed hardware and wetware to detect human pathogens, which addresses human health and safety concerns. In addition, they took biosafety into careful consideration during their design.

Because their sensor includes active genetically modified bacteria, it is important to consider where the sensor chips containing this bacteria go. Rather than integrating the sensor bacteria into the test pad, Aachen decided to separate the test pad and assay chip, which can then be safely sandwiched back in the lab. This clever design decision reduces the chances of accidental release of the sensor bacteria.

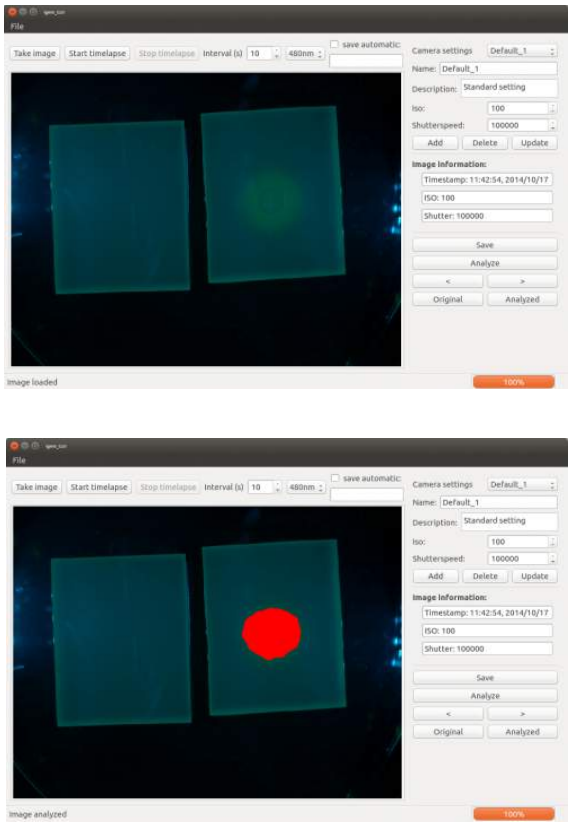


Figure 3: An assay vs a control. Left: unprocessed image Right: the processed image showing detected fluorescence in red.

Measurement

- Instead of making parts, Measurement teams will focus on developing innovative and effective methods for measuring part functions and other characteristics of interest to synthetic biology (e.g., bacterial presence, etc).
- Excellent projects will describe a novel and effective measurement technique that is thoroughly documented on the wiki (i.e., in such a way that it can be reproduced).
- Measurement teams are highly encouraged to participate in the InterLab study.

In synthetic biology, measurement is a critical challenge that is receiving an increasing amount of attention each year. For example, one of the long-standing goals of both iGEM and synthetic biology at large is to characterize biological parts so that they can be more easily used for designing new systems. The aim of the iGEM Measurement Track is to get students informed and excited about these problems and to highlight the successes that teams are able to achieve in the area of measurement. The Measurement Track also aims to find out what measurement assays teams have available and to lay groundwork for future more complex measurement activities in iGEM.

Projects in 2014 ranged from measuring red fluorescent protein (RFP) with a cell phone camera to building functional hardware to measure optical density and fluorescence.

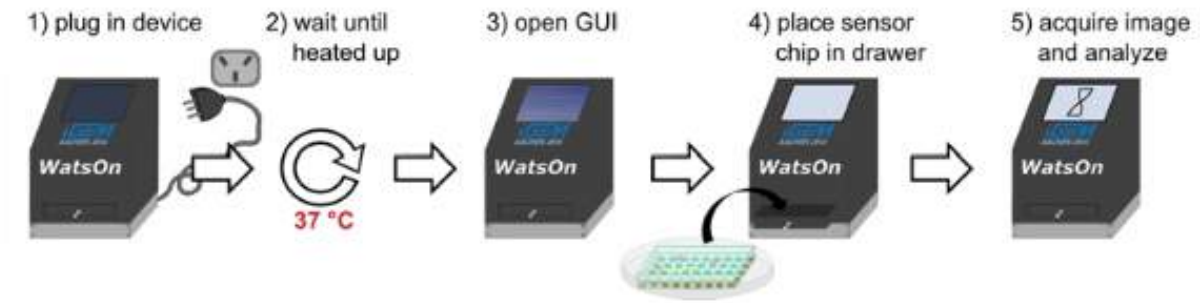
Given the exciting projects and broad interpretation of “measurement” that the teams encompassed, we are excited to see what happens in 2015 and beyond for this track.

Members of the Measurement Track Committee initiated the InterLab study in 2014. This study was open to all teams in the competition and, for 2014, we asked teams to measure fluorescence across three devices expressing green fluorescent protein (GFP) with varying ribosomal binding sites and vector backbones. Measurement directions were intentionally kept vague to see how teams would rise to the challenge, and we were impressed with consistency of the data sent in by 37 teams.

Aachen 2014

Cellock Holmes, the 2014 Aachen project, aimed to detect bacteria on solid surfaces. As a part of this project, Team Aachen designed and built WatsOn, a proof-of-concept do-it-yourself 2D biosensing system (overview schematic shown below). The team used agar chips inoculated with sensing bacteria to determine if their system was capable of detecting other bacteria on a solid surface. The WatsOn system was built using a Raspberry Pi and an Arduino board, which controlled the excitation of LED lights and a Peltier heater for incubation. The team also implemented the WatsOn software complete with a graphical user interface, backend scripts running on the Raspberry Pi, and the code needed to run the Arduino board.

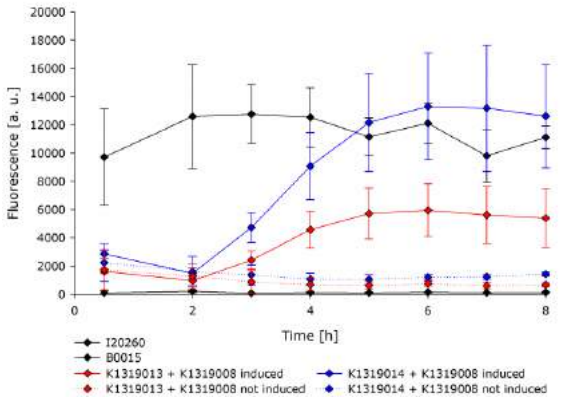
To complete this package, the team also created Measurarty, an image analysis software component used to interpret the images generated when the inoculated agar was placed inside WatsOn, where it was incubated and exposed to specific LED wavelengths. Combined, WatsOn functions as expected (described below) and can be built by end users for just over $300 USD, thus allowing researchers with limited funds a way to easily measure and quantify fluorescence. These areas of the project clearly address several key aspects (all teams **aspects 1-6**).

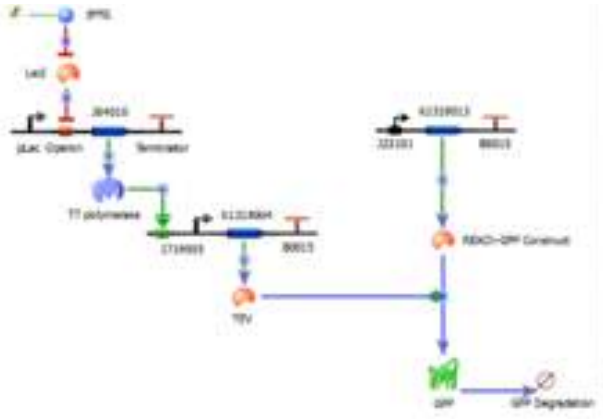


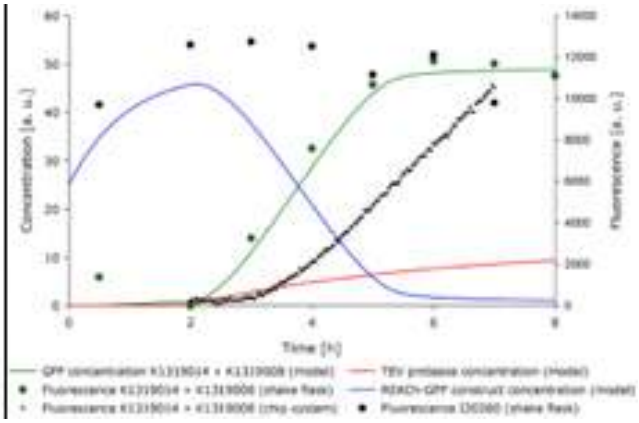
The hardware aspect of the Aachen project was only one part of their work. To detect the presence of bacteria with WatsOn, they needed to create a genetic device that would generate fluorescence. The team chose Pseudomonas aeruginosa as their target organism due to the quorum sensing systems found naturally in P. aeruginosa. The team then engineered sensor E. coli cells, termed Cellocks, to detect P. aeruginosa's native autoinducer (homoserine lactone, or HSL) and then output a fluorescent signal when HSL was detected.

They also took the measurement of fluorescence seriously when designing the genetic devices for testing in the WatsOn system (track-specific **aspect 1**).

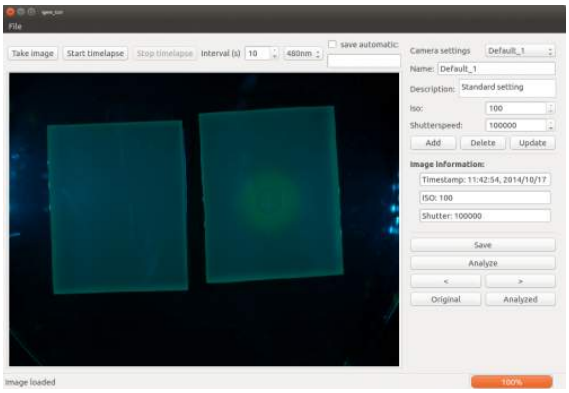
They designed a system that would bind with HSL and output green fluorescent protein (GFP), which they could then measure using WatsOn. Prior to testing these cells on WatsOn, Aachen measured the fluorescence using a plate reader to make sure their devices produced GFP in the presence of HSL; these data were also used to build and refine a model of their system (shown below).

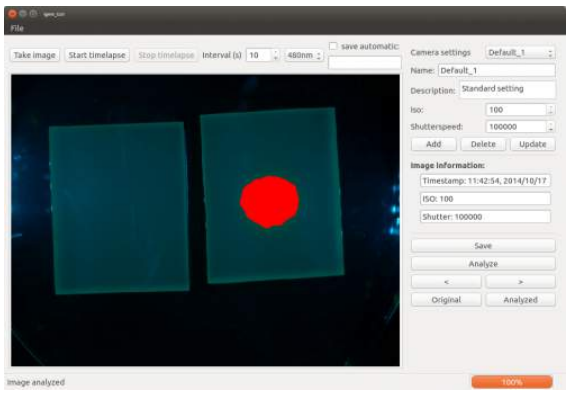


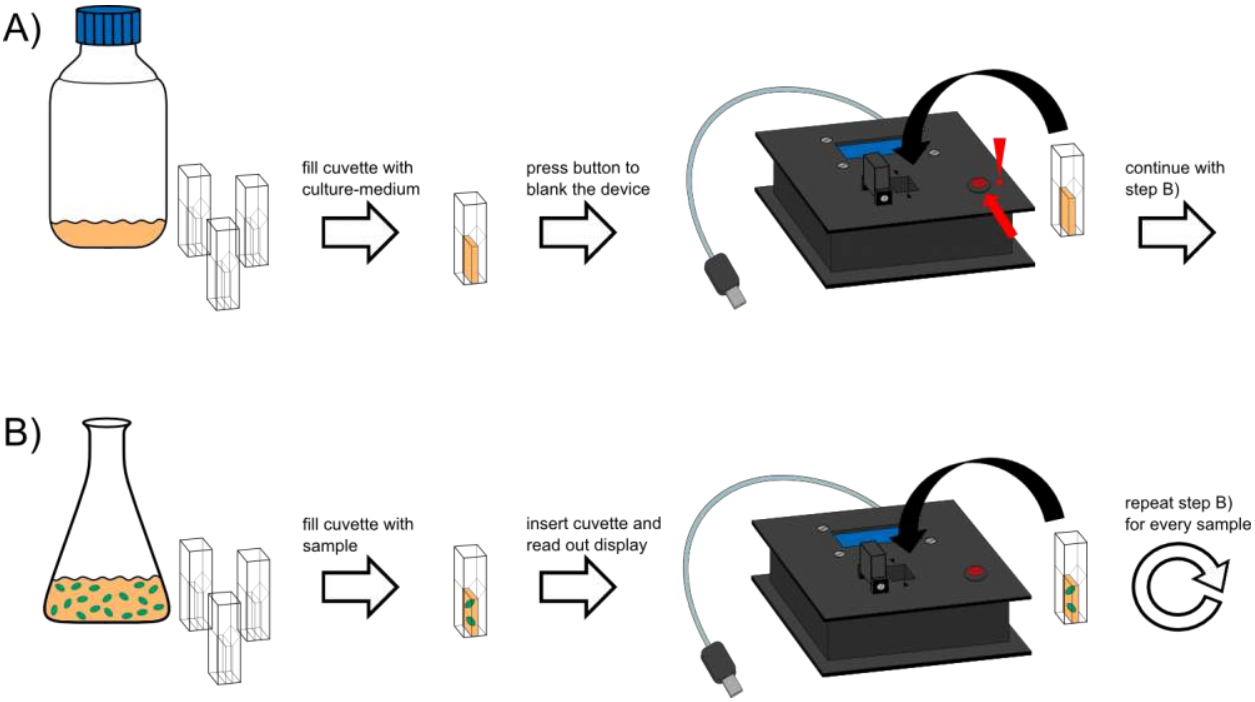




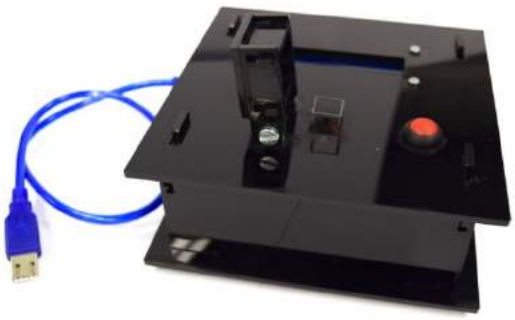
After determining the system worked in liquid culture, the team tested WatsOn using agar slabs seeded with their sensing cells. When P. aeruginosa was present, GFP was produced and clearly seen using WatsOn with and without the image analysis tool, Measurarty (left and right below, respectively).







While Cellocks Holmes was their main project, Aachen also developed a small OD/F Device for users to build themselves that can measure both optical density and fluorescence (see figure above). They were successful in designing, building, and testing a handheld OD/F Device for the cost of $60 USD (all teams **aspects 3, 5, and 6**).



Aachen also explored policy and practices throughout their project. In particular, they took the safety concerns into account during the design of their system, attended a MakerFaire to exhibit their systems, and took the time to reach out and educate the public about synthetic biology (all teams **aspect 7**).

Aachen's project was an impressively complete iGEM project where they executed a well engineered system, both biologically with bacteria and physically with hardware, and took into account the modeling of the biology as well as the safety issues surrounding their work. As a Measurement Track team, Aachen also participated in the InterLab study. In recognition of these achievements, Aachen won Best Measurement Project in 2014. They were also awarded Best Supporting Software, a Safety Commendation, and a Gold medal.

Highlight: Sumbawagen and Aachen Collaboration

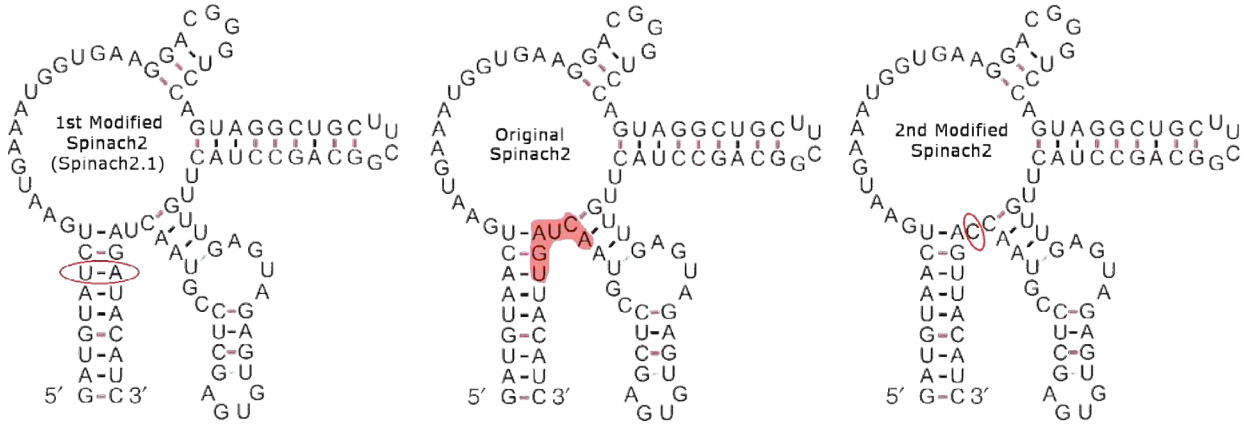
In 2014, one of the best results that came from the Measurement Track was the surprising collaboration that was set up following the Awards Ceremony between Teams Sumbawagen and Aachen. In exchange for some of their native honey, Sumbawagen is going to receive one of Aachen's pieces of hardware that the German team designed and built for the 2015 competition. This hardware will allow the Sumbawagen students to measure optical density and fluorescence, which was impossible for them this year given their long distance from any such equipment (over 1000 km from their campus!). This type of collaboration is what makes iGEM great and we were humbled to have witnessed this exchange. Collaboration is now a silver medal requirement for all teams to reflect the importance of encouraging teams to work together, irrespective of track.

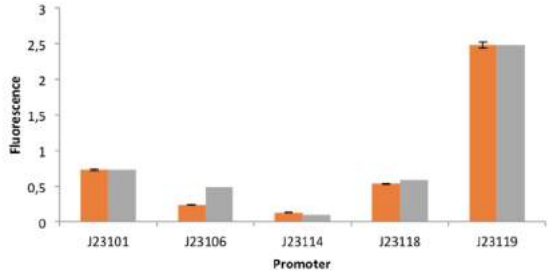
DTU-Denmark 2014

DTU-Denmark's project centered on measuring promoter function through the measurement of RNA production through the use of the Spinach aptamer. The Spinach aptamer binds to a fluorophore when the RNA sequence folds properly, which then activates the fluorophore and thus gives off fluorescence that can be easily measured using GFP filters.

This method is particularly useful because it removes translation efficiency from the measurement of promoter function, which can be a source of variation in promoter measurements.

In their project, DTU modified the Spinach aptamer to remove the illegal SpeI sites in order to generate BioBrick-friendly versions of the aptamer (track-specific **aspect 1**), as shown below.





They then tested the Spinach 2.1 construct using the Anderson library of constitutive promoters and measured the fluorescence through GFP filters. They highlighted five Anderson promoters based upon their expected variation of expression (gray bars in graph below as obtained from the Registry). The measured Spinach 2.1 fluorescence correlated nicely with the expected function (orange bars).

Additionally, they created an in vitro Spinach 2.1 standard that can be used to correlate fluorescence to RNA concentration. This standard will allow future teams to utilize these Spinach aptamers and compare data with other assays. They also used the slope from their standard curve to help estimate the PoPS (RNA Polymerase per Second) for each promoter with the Spinach 2.1 molecule. DTU-Denmark documented their measurement protocol in detail and documented their parts in the Registry (track-specific **aspect 2**).

Strain	Fluorescence	[Spinach:DFHBI]/µM	[Spinach]/µM	CFU/L	Spinach/cell	Production rate	PoPS
101	4.45	3.67	6.11	6.3E+12	584357	248.68	1.24
106	2.21	1.43	2.38	1E+13	140710	59.88	0.30
114	1.59	0.81	1.35	1.3E+13	61741	26.27	0.13
118	3.81	3.03	5.05	7.4E+12	411232	175.00	0.88
119	34.85	34.07	56.78	1.4E+13	2424887	1031.92	5.16

Software

- Software teams will create a novel software tool that supports some aspect of synthetic biology (e.g., methods, systems for representation of data, systems for data organization, etc.)
- Software should be freely available on GitHub such that anyone can view the code and its documentation.
- Excellent software tools should be novel, useful, and well documented.

The iGEM software track judging experience is a little different from that of the wet-lab tracks. You are judging a software tool, a user experience, a scientific project, a mountain of data, and any associated documentation about how the tool was built - all at the same time.

The iGEM software committee values projects that produce, among other things:

New scientific methods for synbio
New visual systems and methods of representing biological data
New methods of organising, managing, or accessing biological data
New methods of exchanging and updating data relevant to experiments or organisms
Innovative approaches to implementing any of the above with novel code
A team that is experienced in both software development and synthetic biology

Thanks to using software repositories like Github, judges are free to browse every single aspect of a software team's project. As such, judging this track can be a very involved process, and you should be prepared to interrogate the code and documentation of each team as much as possible. Ideally, judges should have opinions on code quality before seeing the team's presentation.

When judging software teams, consider projects on the merit of their ideas and the merit of their software. Oftentimes, obtaining data to use on a team's project can be difficult. You should expect to be able to use the software tool yourself, or at the very least be convinced that the tool is usable with a live demo. When in doubt, ask the following questions and arrive at a decision:

What was the overall quality of the tool?
Has the team built a software tool that people would find useful?
Is the software well designed for a synthetic biologist?
Can I understand the documentation?
Would a non-technical person understand the software?
Would a software developer want to use this as a platform for more work?

Remember - be positive with the teams! They take what you say very seriously, and you should give them your support and experience however you can.

How to Judge Small vs Big Teams
In the past, software track teams have won gold medals for creating something “big, useful, and valuable” or demonstrating a tool that is “small, innovative and validated”.

The committee emphasizes that judges should reward innovative approaches to tractable problems in synthetic biology, and you should prioritise this over teams that have favoured making heavy use of shiny javascript libraries over and above “utility in the field”. To put it another way, some teams are much bigger than others, and may have more resources and experience to draw upon to make something pretty. Keep an eye out to make sure all team members have learned about the underlying biology. Furthermore, you should judge each team on its own merit.

Poster Sessions
Poster sessions are a great way to explore the project and interact with the team away from the rehearsed and time-limited environment of a presentation. And you will be able to dig deep on a lot of the questions that you’ll have after reviewing the code and projects. Potential questions to ask include

What part of the code did you write?
Where did you use libraries?
How do you know this is innovative/valuable?
Did you do a prior art study in the field?
Who did what in this project?
How well did you work together and how?
Please explain the project to us?

Speak candidly with all members of the team if you can. It might be that only one person wrote the code, which would not really be in the spirit of the competition - all team members should be contributing in some way, and you must be convinced of this if you are to award a gold medal. Ask questions to help you evaluate if all team members truly understand the project. Although you may experience some communication issues if you and the student speak different native languages, you should be able to distinguish between communication problems and a lack of knowledge of the project. Remember to explain to team members that they can relax during this process! A lot of students will be nervous when talking with a judge - it’s your job to make sure they relax and do the best they can.

Libraries and Innovation
Different uses of libraries can be rewarded in different ways. Judges should reward teams that write their own libraries from scratch, as these can be reused by the community in years to come. This type of project is very much in the spirit of iGEM. Teams can also make valuable contributions to the community when they reuse or alter existing libraries in useful, innovative ways.

At all times, judges should question and think about where the innovation in a project was - did the team innovate on the fundamental biology whilst using libraries, or did they use a library and change a few parameters to make an output look slightly different? In general, we would like to reward when teams appropriately build on previous work, adding their own code and citing the previous work appropriately.

Changes from Previous Years
In the past, the committee advised judges to award gold medals only to teams who had experimentally validated their tool in the lab as a mechanism of ensuring the tool worked and the team understood the underlying biology. This requirement was relaxed in 2015 as the committee found that many team members come from a pure software background. Judges should look for teams that collaborated to solve wet-lab problems with software solutions. Wet-lab teams are very likely to have a problem that can be solved with good software, and so software track teams should attempt to provide additional solutions. This collaboration will encourage software teams to hone their abilities in executing user experience testing, a core software development skill, as well as ensure that a biology team is directing the software team to build useful tools. Any experimental verification that comes out of this collaboration is a bonus.

USTC-Software 2014

BioPano is a software platform targeted for visualisation of biological relationships and cooperative net-building. It was built by UTSC-Software in 2014 to visualize the relationships between different DNA parts and solve the problem of unexpected host-BioBrick interactions (track-specific **aspect 1**). The team introduced BioPano with a clear explanation that made use of a defined problem in experimental biology as well as a clear user need in the lab. The motivation for creating the tool was understandable by a non-technical individual.

USTC-Software demonstrated the relevance of their tool for synthetic biology based on standard parts. They built a "BioBrick Assistant" that allowed the user to directly enter precise numbers of standard parts and obtain parts types in "BioBrick Assistant Windows." The team made use of well-known pre-existing algorithms, and users could use the BLAST function within the BioBrick Assistant. The team demonstrated utility for synthetic biologists by demonstrating that BioPano could, to some extent, predict the impact of a molecule on the host, and it could proactively warn against certain combinations of parts. The implied use of extensive rulesets was reflected in their code.

USTC-Software prepared a comprehensive and well-designed user guide and included it on their wiki (track-specific **aspect 2**). The guide provides details on all functions afforded to the user. In addition, other software developers are able to build on their work thanks to their detailed API documentation, which was automatically built using TOC. In general, teams should attempt to use automated documentation tools where possible.

Teams are encouraged to follow best practises in software development so that other developers can modify, use and reuse their code, with more than one realistic test case.

Examples of best practices are: automated unit testing and documentation of test coverage, bug tracking facilities, documentation of releases, and changes between releases. USTC-Software implemented automated deployment capabilities so that code pushed to their production branch would be deployed to all users within ten seconds, and also worked to employ automated testing on that code, to prevent bugs from surfacing for users. In the case that bugs did make it through, users of BioPano could contact USTC-software, providing them with in-application links to YouTrack, a popular tool for bug tracking and feedback coordination. USTC-software also made their GitHub and GitLab account available to their users. Finally, their server applied automated unit testing to check the legitimacy and function of the code uploaded by a user.

USTC-Software provided a convincing and non-trivial validation of their tests - something which judges should always be looking out for - by demonstrating an analysis of the length of time their heuristic algorithm would take to find more than one path connected to two nodes in a given network. They did this using a pre-existing Python library. Further, they made use of the SBOL format as users could explore data as an SBOL file, keeping in line with this requirement, and also linked nodes with experimental data gathered by other groups.

BioPano produced an incredible project that left all judges wowed in most cases (all team **aspects 1-6**). It was complete, polished, well-thought out, documented, reusable, and professional. The tool could comfortably be used by a biologist wishing to explore the utility of Biobricks in certain hosts. In fact, it's quite hard to see why this wouldn't be an essential tool. The wiki was pretty, the demo video was useful, and the team met all specified requirements.

High School

- 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 like Standard Track teams, with the exception being that High School teams cannot choose a track distinction (e.g., energy, environment).
- 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 rubric according to the language scale, but in your comments and discussions with the teams, remember the potential impact of your words!

Although iGEM was originally founded as a collegiate competition, the high school competition was introduced in 2011. From 2011-2014, high schools participated as a separate division with a separate schedule and their own Jamboree. In 2015, high school teams competed alongside collegiate teams as a Special Track. This year, high school teams will compete as a section.

Historically, high school teams have been judged using a separate rubric that reflected similar values and concepts to the traditional iGEM competition, but with more focus on conceptual understanding and enthusiasm and less focus on experimental success and part functionality. As they are now a part of the Giant Jamboree, they will be judged against the same rubric as the collegiate teams.

When judging high school teams, please keep in mind that most 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 synbio! In fact, it can be difficult to distinguish between the best high school teams and many collegiate teams. To demonstrate this idea, let's look in detail at a couple of teams.

TAS Taipei 2015

In 2015, the team **TAS Taipei** managed to impress the judges with their Granzyme B project. They not only won the High School Grand Prize trophy but got awarded for the Best Wiki and nominated for Best Poster, Best Presentation, Best Education & Public Engagement and Best Composite Part. Granzyme B (GzmB) occupies a major role in inflammatory activities in the human body.

During the inflammatory process, it is overexpressed by the cells as part of the immune response. Amongst other things, its usage is to cleave proteins in the extracellular matrix. As a result, the structure of cells (e.g. tumor cells) can be destabilized. Usually the inflammation decreases over time and the body damage is healed.

Chronic inflammatory conditions can cause abnormally high levels of Granzyme B. The protein then turns into a threat to the healthy cells of the human body by uncontrollable protein cleavage in the extracellular matrix.

The project of TAS Taipei consisted of the idea to reduce the extracellular activity of Granzyme B by delivering a customized inhibitor protein to the inflammatory site. This is meant to be done by coupling the modified inhibitor protein ACT3m with the E. coli motor protein YebF. The latter secretes fused proteins through the bacterial cell membrane. The construct was put under the control of a temperature-sensitive promoter. This device should be integrated in E. coli, which itself should be provided via already used medical treatments like badges or crèmes.

Figure 1: The final construct for the reduction of GzmB. The temperature-sensitive promoter, which is activated by temperatures above 37°C, controls the fusion protein of YebF and ACT3m.

The inhibitor protein antichymotrypsin (ACT) was found during the team's literature search. Subsequently, the sequence was modified in silico on the amino acid level to best fit as an inhibitor for GzmB. The new protein was called ACT3m, which was afterwards fused to the YebF motor protein from E. coli. All together, this construct should provide a functional inhibitor protein outside of the cells. This was positively tested via SDS-PAGE gels (fusion protein is expressed) and biuret reactions (secretion of fusion protein).

The promoter was known to be temperature-sensitive, but the range of temperature sensitivity remained unclear.

Hence, the team tested towards the activation temperature and the time span of the activation by subduing the green fluorescent protein (GFP) to the temperature-sensitive promoter. As shown in the figure below, this part worked (**aspect 3**), producing protein at an appropriate temperature for therapy.

For the development of their prototype, the team integrated their human practice approach into the wetlab results (**aspect 7**). The team thought about the impact of using a GMO as a possible cure. In addition, they surveyed the local public at a science fair. They found that, in order to reduce expectable rejections by potential patients, the application should be as noninvasive as possible.

Hence, team TAS Taipei used a semi-permeable membrane to deliver their protein through a bandage. They checked if bacteria were able to overcome the membrane barrier and if a protein, in this case GFP, could be transferred through it. They found it could not be transferred, indicating that the modification to their design would work.

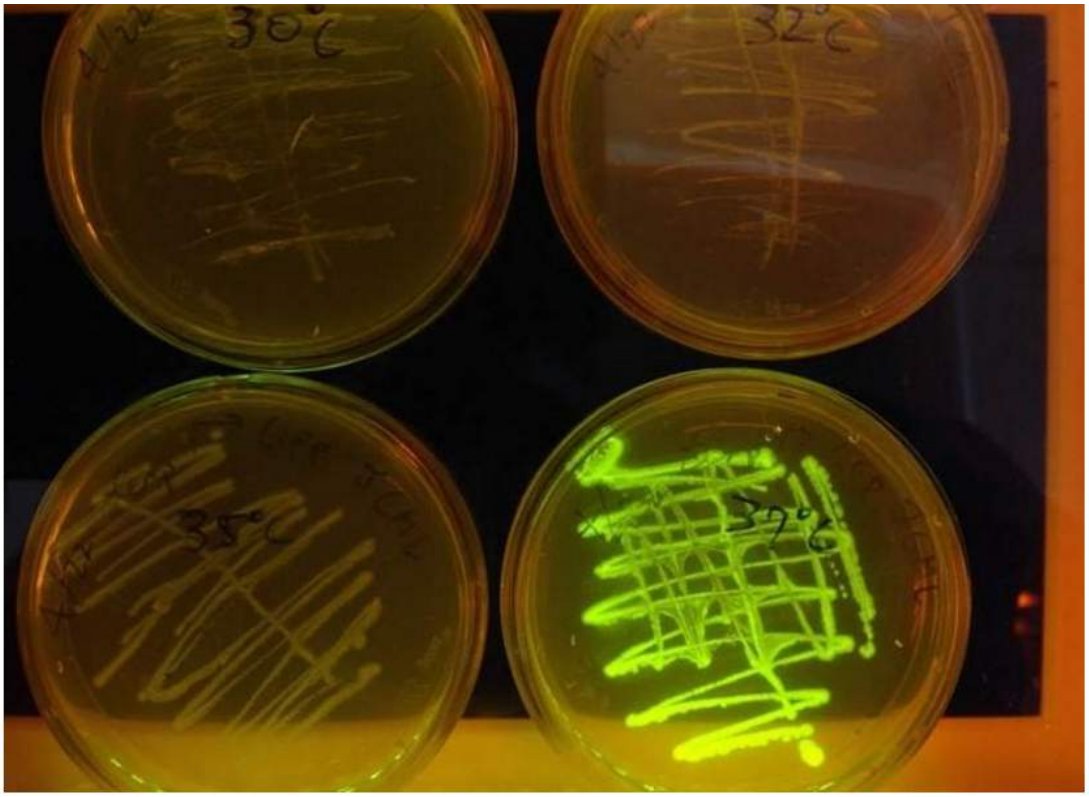


Figure 2: Activation test of the temperature-sensitive promoter by fusing it to GFP. All bacteria on the plates are carrying the construct, but only the ones cultivated at 37°C expressed GFP.

Next to their wetlab work, the team modeled the needed inhibitor concentration for their ACT3m protein. They compared those findings with the already known inhibitor proteins from human and mice. Further, they built a calculator which can be used to determine the perfect concentration for the inhibitor protein that reduces GzmB concentrations to a normal level. This shows good engineering thinking (**aspect 6**).

Beyond the lab bench, team TAS Taipei went full circle with their project by caring about biosafety, requesting advisory help from experts, and drafting an approach to minimize the problem of the knowledge gap. The latter illustrates the dilemma that the broader public might not be in consensus with scientific progress.

This issue was not only tackled but combined with constructive criticism and disclosed in a policy brief sent to non-governmental organizations and political agencies in the US (**aspect 7**).

Overall, TAS Taipei impressed the judges with the breadth of their project and accomplishments (**aspects 1 and 4**). Not only did they create parts (**aspect 9**) that were shown to have some function (**aspect 3**), they used engineering principles in modeling the part's functional parameters (**aspect 6**). Additionally, the team discovered potential societal concerns and as a result integrated human practices ideas into their work (**aspect 7**). Finally, the project seemed to be designed, driven, and executed by the team with only small technical help from advisers and others (**aspect 8**). All in all, TAS Taipei 2015 did an excellent job.

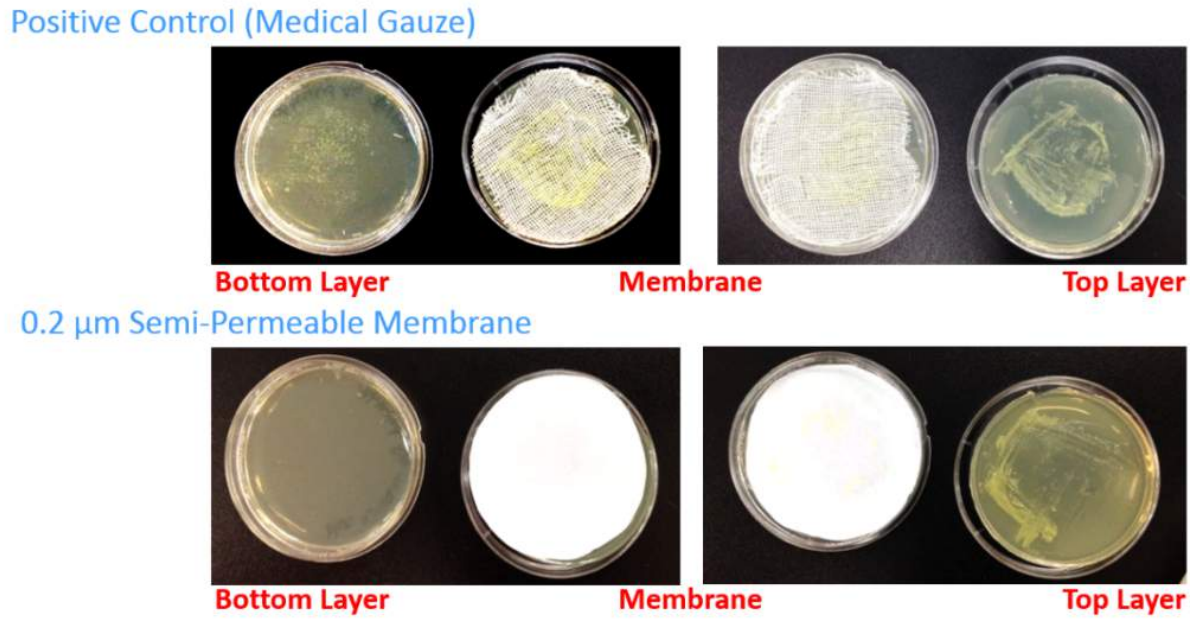
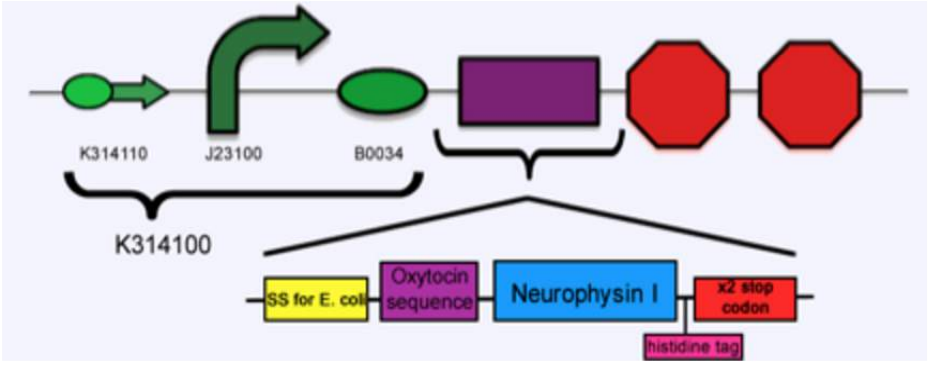


Figure 3: Testing setup for the semi-permeable membrane. The semi-permeable membrane is sandwiched between two layers of agar. Only the top layer contains bacteria, which is unable to pass through the membrane. Medical Gauze was used as the positive control.

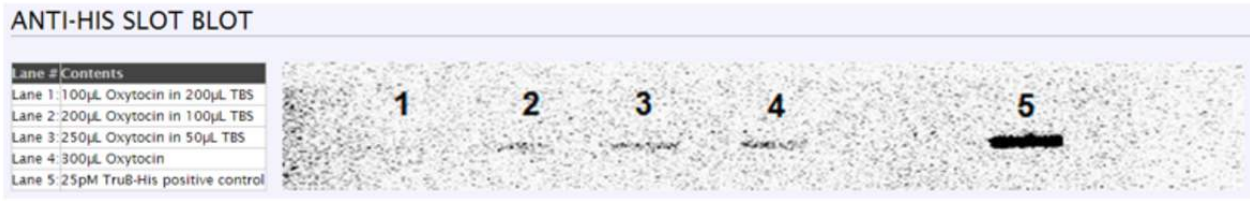
Lethbridge 2013

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:

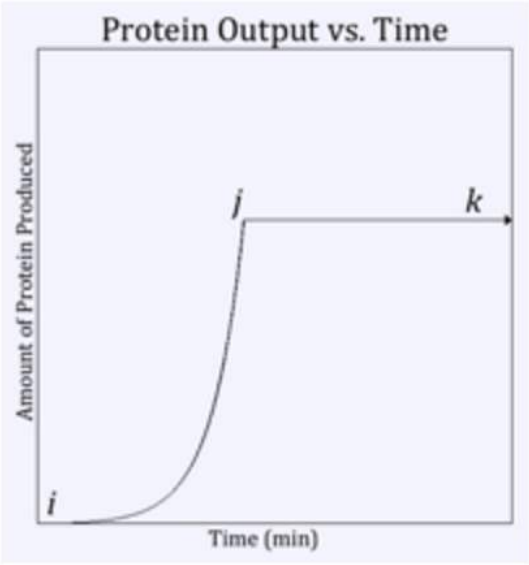


The team was able to completely clone this part, as shown by the **experimental data** on their wiki. Even more impressive, the team was able to express the protein, as evidenced by a slot blot:



Lethbridge 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** to help determine the correct promoter to use. Although the model is fairly basic, it is well documented and thoroughly explained on their wiki.

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



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 (**aspect 7**).

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 (**aspects 1, 3, and 4)**. These qualities made Lethbridge Canada a winning high school team.

FINAL WORDS

Final Words

We have written this document 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, from the perspective of someone who has some biology knowledge, but may not know about software, hardware or other areas. For this reason, there are examples from hardware, software and other special tracks, but not from foundational advance, health and medicine, environment or other standard tracks, other than when they have won.

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. Use this handbook to learn how we value excellence and as a reference manual if you need information on a specific area.

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 hq [AT] igem [DOT] org with "Judging Handbook Questions" in the subject line.

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

Acknowledgements

We are excited to present this expanded handbook to the judges this year and hope that it will be a valuable reference for both veteran and rookie judges. This resource would not have been possible without the help of many of our contributors. In particular, we would like to thank the efforts of Martha Eborall, King Chow, Roman Jerala, Raik Grünberg, Ed Perello, Gil Alterovitz, Jenhan Tao, Evan Appleton, Emma Frow, Megan Palmer, Dan Grushkin, Christina Agapakis, Will Canine, Dave Kong, Janet Standeven, Jake Beal, Traci Haddock, Todd Kuiken, Barbara Di Ventura and Jason Kelly.