Running a successful iGEM Team

Wayne Materi , PhD.
Assistant Research Officer
Nano Life Sciences
National Institute for Nanotechnology
Edmonton, Alberta CANADA

1) Starting up

1.1) Synthetic Biology

The goal of Synthetic Biology is the application of engineering principles to biological entities. The www.syntheticbiology.org website has the following definition:
A) the design and construction of new biological parts, devices and systems.
B) the re-design of existing, natural biological systems for useful purposes.

1.2) The goals of iGEM

The main goal of iGEM is to foster the development of Synthetic Biology through an undergraduate competition.

1.3) What is success?

The goal of this document is to help your iGEM team to be successful. Our aim is to help teams to achieve Gold (or, at least, Silver) medal status. If teams come up with a great project, execute it well and happen to catch the eyes of the Judges, they may even make it into the Finals and/or win one of the named awards. However, a lot of back-room maneuvering goes into selecting the iGEM finalists and winners and nothing will guarantee getting to that point. The suggestions contained in this document should increase any team's chances, though. Other measures of success might include the following:

- getting published
- getting publicity locally or nationally
- continuing the research in a more highly funded way
- recruiting graduate students

1.4) Timing -- the iGEM cycle

The iGEM cycle starts and ends with the Jamboree held in early November of each year. After reviewing the results of the Jamboree, you should start organizing for next year's team almost immediately. While it is possible to assemble teams just before the start of summer semesters (i.e. April or May), this only gives enough time to pick a project, perform a bit of modeling and maybe make a part or two. Successful iGEM teams actually accomplish much more than this, so starting early is a good idea. A useful first step is reviewing what the most recent winning teams have done and identifying the best characteristics to emulate.

1.5) Recruiting team members, instructors and advisors

By definition iGEM teams are comprised mainly of undergraduates (this includes Masters students) though high-school students are also welcome. PhD students, Research Associates, Professors and others are considered to be Advisors or Team Instructors and their role should be primarily instructional.

There are many ways to recruit iGEM team members. Some student groups self-organize after hearing about iGEM, while others are recruited through advertising. If your university has courses on Synthetic Biology, this would be a natural group of students to recruit from. However, the most successful iGEM teams contain

members from a variety of disciplines, including (but not limited to) life sciences, biology, biochemistry, cell biology, microbiology, pharmacology, chemistry, chemical engineering, electrical engineering, computer engineering, computing science, web programming, mathematical biology, business, graphic arts, social science, and philosophy. Thus a broad advertising strategy is likely to be more successful in recruiting a well-rounded team.

An iGEM open house in mid-January, with a presentation by the previous year's team and instructor, followed by a mixer provides a natural focus to a recruiting strategy. Advertising should be directed towards having a good turnout at the open house as this provides an excellent place to describe Synthetic Biology, iGEM, the kind of people required for the team and the general level of commitment required. The optimal team size is probably between 8 to 12 members in total, but successful teams have had from 6 to almost 30 members.

In the formative years of iGEM at your university, you may receive only a few applications and choose to invite all of them onto the team. For universities with medical schools, a number of applicants may see this as an attractive research addition to their c.v.'s. As the popularity of the iGEM competition increases, you will face the decision to either make membership competitive or split applicants into two or more teams. Each additional team will require its own resources, so the number of teams one area can support may be limited. In addition to specific skill sets, successful iGEM members also exhibit considerable initiative, ingenuity and innovation, so selecting for these personality traits may be more important than good grades and experience. Teams also need to have the right group dynamic or chemistry, so it might be wise to use the recruitment process to have a brainstorming session and watch how different groups of people work together.

You may want to use a brief questionnaire like the following to help in the selection process:

-iGEM Team Application-

Name (Last, First):
e-mail address:
phone:

Year/Program:

GPA from two most recent terms:

Relevant course experience:

Career/education aspirations:

Why you want to participate in iGEM:

Why you think you would make a good iGEM team member:

What you want to make or do with this technology:

A critical element for successful iGEM teams is a high-level of technical and scientific support. Teams require such support to assist with complex molecular biology and instrumentation. In addition, considerable training is required in the science of Synthetic Biology and in the many support activities an iGEM team engages in. These may include wiki construction (and HTML), giving presentations, making posters, proper scientific documentation standards, communication among team members, organizing teams, fundraising,

etc. Thus iGEM requires a minimum of two team instructors to provide support and training activities. In addition, other scientific and technical advisors or instructors will greatly enrich the iGEM experience for everyone.

It is important to recruit additional instructors and advisors as appropriate for each team. Instructors are required to commit a fairly large portion of time to the team in order to maximize training effectiveness so they will need to be assured of some return on their considerable investment. Instructors benefit greatly from their iGEM participation as it may help them to identify potential grad students that demonstrate exceptional ambition and initiative. In addition, iGEM projects frequently can be extended and expanded into excellent projects for grad students or post-docs as they raise many interesting scientific and engineering questions. Particularly strong projects could bring in new grant funding or form the basis of commercial ventures.

Besides the active members for the current year, successful iGEM teams are always thinking about the future. iGEM experience increases the team's odds of success. You might consider recruiting two or three second-year students to the team with a specific mandate to just learn about Synthetic Biology and iGEM and to help form the core for the next year. Ideally, each team should have some senior members from the previous year, who drive the majority of the ideas and actual work of the current team, and some junior members whose primary responsibility is to learn.

1.6) Full-time or part-time, volunteer, course or paid

One important issue in formulating the iGEM team is whether it will include both full-time and part-time members. Full-time students working over the summer and/or fall semesters will be able to accomplish more in the lab than volunteer part-timers, so most teams include full-time people for at least part of their duration. The risk of mixed teams (both full and part-time) is that it is possible to create two classes of students on the team, leading to clique formation and resentment. On the other hand, having only paid, full-time team members is beyond the reach of most institutions.

A balanced approach is most likely to be successful. However, all students should commit to an equal amount of volunteer time for the team and, if they are lucky enough to be able to work full-time on the project over the summer, that volunteer commitment should not be changed. In addition to time over the summer, students will need to spend time in the winter/spring learning about SynBio and iGEM and planning their project. Also, the fall semester leading up to the Jamboree requires a substantial time commitment so presentations and posters can be prepared and perfected. Students' first priority should generally be to their course work, so incorporating a SynBio course, directed studies or project course into the iGEM cycle can be an excellent way to encourage their participation and to reward them for their efforts.

Ideally, then, student iGEM participation might look something like this:

1)Winter/Spring semester – 6-12 hours/week in courses (directed readings or SynBio)
– project planning, feasibility

2) Summer semester – 2 to 15 full-time students (plus 10 volunteer hours/week each)
- volunteers contribute 10 hours/week
- lab experiments, assays, wiki design, documentation
- surveys, business plans, etc.

3) Fall semester – most students spend 6-12 hours/week in a project course
- presentation, poster, final lab work, wiki documentation
- analyze EEELS issues data (ethical, environmental, economic, legal and social issues)

Because of the heavy time commitment for students, having courses to start and to complete the projects in

the Winter and Fall, respectively, will enable them to participate fully.

1.7) Team Agreements

The commitment from team members is sizable, though the potential rewards are large and include participation in team-oriented, multi-disciplinary research, opportunity to exhibit/develop scientific entrepreneurial skills, travel to Boston, possibility of publication, public exposure, among others. Team members will also have expectations about what they will get from the experience, including: learning about SynBio, wet-lab experience, modeling experience, presentation training, bioinformatics training, public speaking, etc. In order to avoid disappointment and recriminations, it is important to develop an agreement among team members, advisors and instructors that outlines the commitment of each to the other. We provide the following template:

iGEM Team (team or project name) Agreement

Because participation in an iGEM Team project is a privilege, an honor, a challenge and a joyous celebration of science and engineering, we agree to the following guidelines:

Students:

- to commit our intellect and energies to the fulfillment of the team goals
- to learn the principles of Synthetic Biology and the science behind our project
- to conduct ourselves and our research to the highest scientific and ethical standards
- to represent the ideals of Synthetic Biology and iGEM in a fair, balanced and open manner to the general public
- to work a minimum of xxx weekly volunteer hours during the project planning phase
- to attend a full weekend Basic Molecular Biology course held <dates>
- to work a minimum of xxx weekly volunteer hours during the project execution phase
- to work a minimum of xxx weekly volunteer hours during the Jamboree preparation phase
- to attend all group meetings and learning sessions or to notify coordinators if impossible
- to travel to the Jamboree (and other local events) and participate joyfully
- to work hard, learn lots and have fun

Instructors/advisors

- to commit our intellect and energies to the fulfillment of the team goals
- to learn and teach the principles of Synthetic Biology and the science behind our project
- to train students in all the skills and techniques required in the project or to find suitable instructors, where required
- to conduct ourselves and our research to the highest scientific and ethical standards
- to represent the ideals of Synthetic Biology and iGEM in a fair, balanced and open manner to the general public
- to work a minimum of xxx weekly volunteer hours throughout the project
- to attend all group meetings and learning sessions or to notify coordinators if impossible
- to travel to the Jamboree (and other local events) and participate joyfully
- to work hard, teach/learn lots and have fun

Signed: Date:

1.8) Building SynBio and iGEM background

Obviously, a Synthetic Biology course is the best way to teach undergraduates about SynBio principles. For institutions lacking such a course, we recommend that the first few team meetings are used to teach some relevant basics. A large number of review articles are available that discuss SynBio principles including the

following:

Andrianantoandro, E., S. Basu, D. K. Karig, and R. Weiss. 2006. Synthetic biology: new engineering rules for an emerging discipline. Mol Syst Biol **2:**2006 0028.
Drubin, D. A., J. C. Way, and P. A. Silver. 2007. Designing biological systems. Genes Dev **21:**242-54.
Endy, D. 2005. Foundations for engineering biology. Nature **438:**449-453. 11.
Heinemann, M., and S. Panke. 2006. Synthetic biology--putting engineering into biology. Bioinformatics **22:**2790-2799.
Marguet, P., F. Balagadde, C. Tan, and L. You. 2007. Biology by design: reduction and synthesis of cellular components and behaviour. J R Soc Interface **4:**607-23.

In addition, past proceedings of some Synthetic Biology conferences are available online. For example, web-casts from the international SynBio conferences SB1.0 to SB4.0 are available by following the Conferences links at www.syntheticbiology.org.

The best way to learn about iGEM is to participate, but the second best way is to review previous competitions. Fortunately, presentations, posters and wikis are available online through the most recent iGEM.org website (e.g. 2008.iGEM.org). We recommend spending a few planning sessions in January or February to review past projects.

1.9) Getting project ideas

Generating iGEM project ideas is not necessarily all that difficult once some familiarization with Synthetic Biology has been achieved. Using a Directed Readings or Synthetic Biology course as a source of good project ideas is also likely to result in better thought out, scientifically sounder ideas with more application potential. Following some basic instruction on Synthetic Biology and past iGEM projects, you should hold focused brainstorming sessions to generate some basic ideas. Individual team members or groups of two should then elect to champion some of the ideas. This process should entail conducting deeper literature searches and developing one or two page proposals and very brief presentations to pitch their ideas to the rest of the team in subsequent meetings. A couple of meetings may be required before the team selects their favorite/best project.

A team should only have one project, although it may contain multiple sub-projects. If a team cannot settle on just one project, consider splitting them into two separate teams. The most successful iGEM projects contain elements of mathematical modeling or simulation, molecular biology, assays of results (perhaps, with instrumentation development) and thoughtful examination of EEELS (ethical, environmental, economic, legal and social) issues.

1.10) Team Building

It is important that the iGEM Team actually work like a team. Getting individuals to commit by signing the above agreement is only the first step. Conducting brainstorming sessions during the Winter/Spring meetings is also a key element in building team spirit. Consider holding some of these sessions in a more social environment (but one which permits some work to be done) to help build interactions and trust between the team members. Team members also need to work in a rich communication environment, which can be difficult with young scientists and engineers. Establish standards for documentation and encourage team members to share their results, problems and thoughts among each other and with their advisors. Operating a journal club where team members read and discuss a single paper can help facilitate this, depending on the time available. Also, project milestones and deadlines can help heighten the sense of urgency and adventure, which will often help teams to coalesce.

1.11) Building support networks

In addition to the team instructors, successful iGEM teams reach out to the academic, commercial or general community when they need to recruit additional expertise. The more extensive and effective the network of specialists and consultants, the less likely the team is to become bogged down in problems and the more they will feel part of something important. Encourage network building by having team members identify professors or companies that have valuable information, then contacting those people to ask for help or just to invite them for a chat.

1.12) Lab space

Lab space may be contributed by team instructors or a sponsoring department/company. The minimum useful time for lab space to be available is May to September for North American teams. If at all possible, try to find permanent lab and meeting space for the team as this will permit year-round use. This will be especially important in the Fall as the Jamboree approaches and lab work needs to be finished in a hurry.

1.13) Funding

There are a large number of funding sources available to assist with the iGEM team and many ways to approach the funding question. One fundamental question each team will need to answer is how much fundraising to attempt and what sources to focus on. Some projects are very suitable to approaching specific industries, such as biotech, energy, or pharmaceutical companies. Other teams will have easier access to more traditional forms of academic funding. To a certain extent, some element of fundraising should exist in all iGEM projects, as the entrepreneurial experience is an important element of iGEM. Cynical team members will be surprised at how receptive potential funding sources are to contributing to their projects.

1.14) Publicity

Publicity can be a key element for teams as a recognition of effort, promotion of their school or institution, attracting new team members, rewarding sponsors and sourcing new ones, developing new course programs, etc.

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2) Exploratory planning

2.1) Planning the project

After acquiring some familiarity with Synthetic biology, in general, and the iGEM competition, specifically, and after selecting a project, a detailed planning process should begin. A successful iGEM project has an incredible number of elements, parts and circuits to be designed and made, models to be written and tested, data to collect and analyze, presentations, posters, T-shirts, wiki pages, fundraising, travel, etc. This would be overwhelming for any one person, so it is important to delegate (see below) and coordinate. A dedicated Project Manager elected from the Team, might help this process (and subsequent execution of the plan) considerably.

Start with a broad plan. The general Project should already be defined and the team should have a good idea

of all the many things that need to be done to accomplish their goals. The Plan can be fleshed out in more detail either by the whole team or by small working groups dedicated to particularly parts of the entire project. Some parts of the project, such as the poster or presentation, will need to be planned at a later stage, once progress has been made and (perhaps) data collected. Planning along with progress reporting should be a continuous process driven by the Project Manager.

The scientific portion of the project is the most likely to contain the greatest challenge for the team and will likely require considerable input from advisors and instructors. Effort expended at this point in the project will not only greatly enhance the chances of a successful conclusion, but also reduce the amount of work required throughout the summer and fall.

2.2) iGEM requirements

The iGEM organizing committee changes the requirements every year, so it is somewhat of a moving target. However, certain constants remain. The basic requirements for a minimally successful project usually involve completing a team wiki, presenting a poster and talk at the Jamboree, and submitting a BioBrick part. Higher levels of achievement require making and characterizing an existing or novel working part and contributing to the Synthetic Biology or larger community. It is important to review the Judging Criteria each year on the iGEM home site and to plan team activities to meet those criteria.

In past years iGEM has awarded Bronze, Silver and Gold medals to teams based on their published Judging Criteria. In addition to these, a number of named awards are presented (including the Grand Prize aluminum BioBrick) based on various criteria, such as Best Poster, Best Presentation, Best New BioBrick, Best Model, etc. These also change from year to year, so it is important to check the Judging Criteria for the current requirements. Generally only Silver and Gold medalists are considered for named awards, though this is not a set rule.

2.3) SynBio project

Recall the www.syntheticbiology.org website definition of synthetic biology from above:
A) the design and construction of new biological parts, devices and systems.
B) the re-design of existing, natural biological systems for useful purposes.

In addition, the site lists the following sub-goals:

1. help specify and populate a set of standard parts that have well-defined performance characteristics and can be used (and re-used) to build biological systems,
2. develop and incorporate design methods and tools into an integrated engineering environment,
3. reverse engineer and re-design pre-existing biological parts and devices in order to expand the set of functions that we can access and program,
4. reverse engineer and re-design a 'simple' natural bacterium,
5. minimize the genome of natural bacteria and build so-called protocells in the lab, to define the minimal requirements of living entities, and
6. construct orthogonal biological systems, such as a genetic code with an enlarged alphabet of base pairs.

An iGEM project should satisfy some of these criteria at a minimum. In addition, the iGEM judges have historically demonstrated a preference for applications that potentially benefit society or the Synthetic Biology community.

Planning the science and engineering that will comprise the project will require several members of the team to understand the project principles and the tools that will be used to execute the project. These may include cells, DNA, BioBrick parts, plasmids, enzymes, molecular biology, genetics, biochemical assays,

microscopy, software, programming languages, etc. Where possible, instructors should include specific small courses or reference material that will help team members acquire the knowledge and skills they require. Clearly, though, the individual drive and initiative of team members will greatly determine their success in acquiring the necessary knowledge. To a large extent, this explains the importance of these characteristics even over background and knowledge in determining the success of the team.

2.4) Modeling

A number of modeling tools are available and may cover a large range from basic biochemistry texts to Mathematica or other simulation software. Having modeling expertise available is critical to the success of this portion of the project. Some good introductory texts are:

2.5) Instrumentation

Characterizing a BioBrick part is an important component of any iGEM project. Several more often used assays of gene expression include LacZ, GFP, Northern blots, Western blots and other biochemical assays. A variety of instrumentation may be available to your team but specialized instruction is often required to operate an instrument safely and reliably. Seek help from team instructors and advisors.

Some iGEM projects may need to develop their own simple instrumentation. For example, digital cell tracking systems consisting of cameras and software have been developed by past teams.

2.6) Open source

iGEM projects, BioBrick parts, and wiki documentation are all considered open source, that is belonging to the community at large. There is a debate as to whether wiki's should be used as ongoing documentation tools or uploaded on the due date. We believe that secrecy, even for the sake of protecting your project from possible competitors, has no place within iGEM and should be actively discouraged. We, therefore encourage teams to utilize their wikis as active, public documentation of their efforts.

2.7) Documentation and labeling

Good documentation serves multiple important purposes: it provides support for any intellectual property claims; it provides factual support when writing papers; it tells both you and other team members what to do to repeat an experiment; it helps to organize your thinking and planning. Most importantly, documentation is the **public** property of the entire team and it must be written for the entire team. Standards of documentation will reduce the amount of work that is required for one team member to understand the work and the thinking of another. We should document all work so that any team member could look at any other member's lab book and understand it easily.

1. The basic goal of good documentation is to communicate as efficiently as possible. Write everything that needs to be written; but nothing more. In particular, do not repeat what has been previously written, when a simple reference to a book and page number will do (plus a few notes remarking on what is changed in the current experiment).
2. Use the appropriate lab book or wiki. While most documentation is kept in diary form, having the ability to organize it by project, sub-project or person is very useful for finding data quickly.
3. Document your thinking (Rationale or Purpose) along with the Experimental Protocol or Procedure **before** you begin the experiment. A hard copy lab book should always accompany you in the lab, except when performing the most mundane and repetitive of tasks.
4. All constructs should first be "assembled" electronically *in silico*. This greatly reduces the number of errors, as computers can easily check conflicting restriction sites and reading frames for fusion

proteins. The BioBrick web site, among other available tools, provides construction capabilities.

5. As you perform an experiment (or make a construct) any changes to the expected protocol can be entered, along with the results.
6. Standard or obvious steps need not be entered. However, standard protocols (found in the Reference binder, in Sambrook et al. or in various commercial kits) should be referenced, as should protocols adapted from published work. These references greatly simplify the task of writing articles based on your work. There are far fewer "obvious" steps than one might think. Most of these are (or should be) in some standard protocol. Almost everything else should be written down.
7. Many steps in protocols involve the mixing of a number of reagents in a standard reaction such as a restriction digest, PCR, ligation, etc. While it is not necessary (or even desirable) to write a detailed description of how each reagent was added to the tube (this is either "obvious" or left to personal taste), it is **critical** to always list all the reagents and amounts used in this particular experiment. As reagents are added, they should be checked off in the lab book so as not to lose one's place. this practice also helps focus the experimenter on their work. Other reaction conditions, including times and temperatures, should also be recorded. Running conditions, such as percent agarose gel, voltage and time should also be recorded.
8. Supporting documentation produced by lab equipment should usually be included in the documentation. Electronic images or scanned images may be uploaded to the wiki. Documents that are not uploaded due to space limitations, should be filed carefully and cross-referenced in the wiki. Chromatograms may be held in binders, for example. Attached documentation should be annotated so that it is clearly related to the information in the wiki. For example, gel lanes should be marked and any bands cut-out should be marked. Electronic copies should be stored and the file name and computer and folder (or directory) should be marked in the wiki.
9. Lab notebooks often reference material that is online on some computer file. In this case, the lab book and computer documentation should be cross-referenced and must be in agreement. At the very least, the same name must be used to describe the same construct in both sources.
10. Every experiment should end with some conclusion. Either something was made, verified, proven, disproven or inconclusive, needing further work. In the latter case, problems and subsequent or alternate approaches should be discussed. At the very least, when no solid conclusion is possible, a link to the next page that continues the experiment should be included.
11. Most experiments (and **all** projects) take place over a number of days and may be interrupted by other work. The inclusion of "continued to" and "continued from" fields on each wiki page should assist in providing continuity, as should a table of contents.
12. Complete documentation standards should be developed on a continuous basis by the team.

Good labeling and storage of plasmids, glycerol stock, plates, intermediate constructs, etc. is **absolutely crucial** in enabling team members to find and identify the reagents they need. In addition to being correct and complete in their descriptions, we also need to ensure that using the labeling and filing systems does not become the major work activity; systems must be effective but efficient. The following system has been developed through many years of experience (both in the lab and in systems design) and considerable attention has been paid to making it match these criteria. However, these standards are intended to be dynamic and subject to the consensus of the project team. Consider them suggestions for the start of an effective communications protocol.

Ep tubes (microfuge tubes, 1.5 ml tubes, etc.)

1. Give **every** tube a label, even temporary ones.
2. Labels for permanent constructs should have a name or number that is described by an entry in a lab book or wiki. Naming conventions and allowable part numbers for a team are designated by iGEM HQ each year. Following sequence verification, a colored label should be affixed to the top of a permanent construct and it should be stored in the appropriate -20ºC box.
3. Permanent DNA (i.e. any finished and verified construct) should have the date and a page reference number (page where final sequence was verified) on the side of the tube. For example, this might look

like 00050-128; where the first 5 digits are the book number and the last three are the page number.

4. It is never necessary to write "miniprep" on a tube as this is the default. Other "in progress" markings may be used as follows (for 1.5 ml tubes):
    1. "/" means "treated with enzymes…". For example WM0302/EcoRI+PstI means WM0302 digested with enzymes EcoRI and PstI at the same time (i.e. a double digest). /EcoRI/PstI means digested with EcoRI then with PstI. This allows you to describe a string of treatments, including dephosphorylation, phosphorylation, blunt ending, etc.
    2. PCR products should say "PCR" on the tab of the tube. It is not necessary to put primer names on the tube, though the tube should be cross-referenced to the lab book.
    3. Gel cutouts (fragment in gel) should have the fragment size along with restriction enzymes used or "PCR" on the tube.
    4. Gel-purified fragments should have a "P" on the tab. Digests or PCR used to produce the fragment should be noted.
    5. Ligation mixes should have an "L" on the tab of the tube. Ligations may specify the two components being ligated, but it is better to give them a new construct name.
5. A series of "in progress" tubes (e.g. several plasmids all subjected to the same digest) may be numbered "1, 2, 3,…" or "a,b,c,…" or any other meaningful system. The first tube in a series should contain all the information expected for a permanent DNA tube. It should have a clear, descriptive label on the top and a date and lab book page reference on the side.
6. "In progress" tubes may be stored in plastic racks or in more permanent freezer boxes in the -20ºC freezer. In general, racks should only store tubes while the tube contents are under active (i.e. at least twice a week) use. Tubes left untouched in racks for over a week should be returned to their proper freezer boxes.
7. Freezer boxes (both -20 ºC and -80 ºC should be labeled by project NOT by person). The team should cooperate to develop project labels for boxes.

Glycerol stock

1. For every new construct, and for every construct in a new bacterial strain, a glycerol stock must be made shortly after verification of the construct and stored at -80ºC.
2. The name of the construct should be written on the top of the tube and the side of the tube should have the construct name, host bacterial strain name, date, and lab book reference.
3. A label maker may be used for this, if there is not adequate space for handwriting.
4. For strains with no construct, the strain name, date frozen, and lab book reference is sufficient. The lab book entry for a received strain should document where the strain came from, its genotype and phenotype, and a relevant published reference.

PCR tubes and strips

PCR reactions, digests and ligations (among other reactions) can all take place in 200 µl PCR tubes or strips. These have little or no space for writing so special conditions apply.

1. Generally one or two digits or letters can be written on the side of the tube. This should be adequate to identify the tube on the day it is used, by consulting the responsible person or their lab book.
2. When PCR tubes or strips need to be stored for longer, they should be placed in the appropriate rack and a labeled piece of tape placed over or beside them. The label on the tape should follow the same rules as for 1.5 ml Ep tubes, including a descriptive name, date, and lab book reference.

Culture tubes

1. Culture tubes are generally temporary and can be labeled on the side of the tube (on the glass) or on the side of the lid. The side of the tube is preferred because the lid can be moved to a different tube. Also Sharpie writing on glass is easier to remove than on plastic.
2. Bacterial strains should be labeled as for glycerol stocks.
3. Tubes are frequently used in a series. In this case similar rules as for series of Ep tubes, can apply.
4. Culture tubes often add antibiotics or other chemicals into the media. The first tube should record all the pertinent information when all the rest of the tubes are similar. Tubes with different antibiotic or

chemical treatments should record these on each individual tube.

Plates

1. Plates with bacteria may be used for very short or medium term. In addition to identifying plasmids and bacterial strains on the plate, growth and experimental conditions also need to be identified.
2. Generally, labeling should be consistent within the team. Plates are always labeled on the bottom, never on the lid.
3. Poured plates should always be stored with the media name and selection chemicals written on them. For example "LB + amp_{50}". Note that the concentration of the antibiotic should be written on each plate.
4. Any addition selection or detection reagents and growth conditions should be added in the same region of the plate as the media description. For example "LB + amp_{50} + IPTG (4ul) + X-GAL (40ul) - 37ºC" might be a full description of the media and growth.
5. With the media and growth conditions on the left side of an inverted plate (lid upside down), the date should be recorded along the bottom of the plate. The strain name and any relevant genotypic information are recorded at the top and experimental conditions are recorded on the right side of the plate. The strain name should follow the criteria for glycerol stocks names. Experimental conditions include amount of bacteria plated, any special conditions, etc. For example, for a standard ligation 150 ul's are usually plated out of the 1000 ul's in the recovery tube; this can be record as 150/1000.
6. For plating ligations, the name of the intended resulting construct should be used but the negative control (no insert) should use the name of the original vector along with restriction digest and other preparatory enzymatic reactions, such as dephosphorylation.

2.8) Presentation and Poster

Planning these is fairly straightforward. Review the efforts of successful past teams and try to emulate them. The standard for both presentations and posters at the iGEM Jamboree is very high. A thorough understanding of the subject material is only the starting point. iGEM teams are frequently more creative and have more fun with their presentations than what would normally be seen at most scientific conferences, so it is important to take this into account.

2.9) T-shirts and memorabilia

Keeping with the theme of having fun at the Jamboree, team T-shirts and other memorabilia should be designed to be uniquely eye-catching and, well, memorable. T-shirts are almost a required part of the Jamboree as it makes finding each other in the hub-bub that much easier. Also team colors allow members to easily find their team in the traditional "picture from above." T-shirts have ranged from fairly standard forms, to soccer jerseys to kimonos. Even other forms of clothing have made their appearance in some competitions, including hard hats. No one has ever done capes.
Other memorabilia include baseball caps, drink coasters, pens, pocket protectors, wrist bands and almost anything inexpensive enough to give away and small enough to transport to the Jamboree. Although not required, the memorabilia make a very nice secondary competition.

2.10) Other creative ideas

Whatever you can come up with.

2.11) Raising funds

The team needs to set funding goals and decide who will be approached for support. A short portfolio, describing the project, iGEM, Synthetic Biology and the team should be compiled by the Funding focus group.

2.12) Publicity

At any early stage, the team should appoint a focus group to deal with publicity. Although it may seem premature to seek PR before anything has been accomplished, successful teams raise awareness (responsibly) at any early stage. Without over-inflating expectations, a team should approach its institutional and student newspapers and put their story out their. If teams are seeking more members, advisors or instructors or if they will be conducting public surveys, this is a good vehicle for raising awareness. Stress the general problem being addressed, the basics and purpose of Synthetic Biology and iGEM at this stage. As the team desires, local news agencies (and, especially, science news agencies) may also be contacted.

2.13) Delegating and coordinating work

Even in the planning stage, the energy level and coordination required to put together a successful iGEM team far surpasses almost any other undergraduate experience. Obviously one person cannot do it all, so work needs to be taken up by team members, either as individuals or small groups. This section has briefly described some of the activities that will need to be considered and planned. While overall planning should be done by the team as a whole, specific areas, such as modeling, lab work, fundraising, presentations, posters, etc. are best done by smaller working sub-groups.

2.14) Team meetings

Team meetings should be held on a regular basis; we recommend weekly meetings. During the Planning phase, the team meetings will help everyone to share in the basic project ideas and to flesh out some details, as well as outline the other work required for the team. Team meetings will likely require 1 to 2 hours, especially if instructional time is required. Team members who are enrolled in specific classes (e.g. Synthetic Biology or Computational modeling) may be excused from specific instructional modules but, otherwise, everyone should attend. Instructors and advisors should attend the business portion of the meeting and may opt to attend the instructional sessions as well.

Instructional sessions may be held either first or last in a meeting. We would recommend carrying out instruction first then moving on to a brisker-paced business meeting afterwards. We realize that the weekly meeting load, including the Focus group meetings (below) may take 3-4 hours per week in this stage and this is a fairly heavy workload on students at this stage. Our advice is that this will not only greatly enrich the iGEM experience for all team members but will reduce the meeting time required over the summer. Obviously, if everyone on the iGEM team can enroll in a course (e.g. directed research option) then more time can be spent that is directly relevant to student members. The actual number of hours and, perhaps, a plan for the meetings at this stage, can be part of the Team Agreement.

Meetings can be held at any mutually agreed-upon time and place. To a certain extent, one of the criteria for participating on an iGEM team should be the availability to attend weekly meetings. Because most iGEM teams contain 6 – 12 members, it can be difficult to arrange a convenient meeting time. We recommend a weeknight during regular semesters and the summer, with special weekend meetings during the Fall to prepare for the Jamboree. A commitment to attend meetings is crucial to team spirit and to its eventual success. Nothing is more discouraging than team members who can't bother to show up for a weekly meeting.

A wide variety of instructional sessions could be held during this period, making a mini-course in Synthetic Biology and iGEM. Instruction would preferably be for the entire team, with expanded discussion to focus groups. Some selected topics are suggested below:
- Introduction to Synthetic Biology
- Introduction to iGEM

- Review of past iGEM competitions
- Literature searches and reading primary literature. Pubmed, Google Scholar, patent literature
- Maintaining a lit db
- EEELS issues and studies
- Genetic circuits
- Protein engineering
- Metabolic engineering
- Molecular biology basics (digests, gels, ligation, transformation, sequencing)
- Mathematical modeling
- Bioinformatics and support tools (Entrez, BLAST, Vector NTI, Primer design)
- BioBricks and the BioBrick Foundation
- Biochemical assays and analysis
- Instrumentation (FACS, microarrays, microscopy, etc.)
- Biological readouts
- Advanced molecular biology (PCR, Northerns, Westerns, microarrays, etc.)
- Fundraising
- HTML and wikis
- Powerpoint and Photoshop
- Basics of presentations and posters
- Keeping a lab notebook
- Documentation of parts
- Navigating the Registry of Biological Parts
- Team work and leadership strategies. How to run a meeting.
- Lab safety

2.15) Focus group meetings

Focus groups are subsets of the entire with specific interests and/or skills that can meet separately to address specific sub-tasks. Smaller groups make for tighter working relations and more effective exchange of ideas. We recommend making focus groups to handle planning, execution and management of most portions of the iGEM project. Focus groups can either meet following the general weekly meetings or at some other time convenient for the group.

2.16) Team socials

Even at the early planning stage, iGEM teams are already working hard to be successful. It is important that the team reward itself with some time for socialization. Pizza in the first half of the the weekly meetings before getting down to work is recommended as a minimum. After the weekly meeting, the team may want to get together for beer, coffee, tea, etc. Obviously, having the team members get along socially is almost as important as getting along intellectually, if they are to work as an effective, dynamic team.

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3) Extreme execution

Planning is nice, but at sometime, something real has to be produced. The most effective teams realize that communication at this stage is paramount. Appointing a full-time team manager to maintain a schedule of the many tasks to be done will go a long way towards maintaining everyone's sanity. Taking a pause once a month to ask everyone how the structure of the team and the division of tasks is working may help identify and deal with problem areas. It is also a good idea to check in with how well team members' expectations of each other, of the project and of the instructors are being met. This self-reflective exercise can highlight potential problems at an early stage. If the question is met with silence (rather than with overwhelming cheers of how great everything is) then the team is in real trouble and needs a serious review of its goals. Silence usually indicates that things are not going particularly well and that the team members don't trust each other enough to admit it.

3.1) In the lab

A major goal of the iGEM project is to produce functional, well-characterized BioBrick parts. This will require wet lab work. Because iGEM members come from a variety of backgrounds and levels, experience with molecular biology and other required techniques will vary considerably. It is important to pair more-experienced members (or advisors) with less-experienced members so that transfer of skills and knowledge can take place. We find that it is usually best to hold a Basic Molecular Biology course for all team members that will be conducting wet work. Because of the time required to conduct many basic molecular biology experiments (e.g. digests, gels, PCR, sequencing), it may be most convenient to run a basic weekend course on molecular biology lab basics, realizing that this will not be adequate for people to work successfully in the lab. They will still need assistance for their first few experiments.
Molecular Biology is still a labor and time-intensive activity, though many procedures have seen order of magnitude improvements in efficiency over the past decade. Full-time students will be capable of producing more results than part-time volunteers, so they give obvious advantage to any team. However, considerable work can be accomplished by a committed volunteer team with good ideas and good support. The best of both worlds has a core of full-time summer students supporting a larger group of volunteers. This may require full-timers to work some evenings and weekends during the summer months. Such a commitment should be spelled out in the Team Agreement, remembering that being a full-timer does not remove the obligation to carry out volunteer activities as well.

3.2) Maintaining focus and energy

Eventually all lab work falls into a rut, either because it becomes easy but has to be repeated multiple times on different samples, because nothing is working and the researcher is frustrated, or because science has large mundane stretches in order to verify reliability. iGEM projects are usually so short and intense that there is little danger of this happening until well into the summer. One important thing to remember is that scientists and engineers are just people. We get discouraged by failure; we fall into patterned modes of thinking; we enjoy staying within our comfort zone. Lab work can often be reinvigorated by shuffling tasks among team members and by cross-training. Although this may reduce overall efficiency, it will make for happier team members.

3.3) Surpassing failure

Psychological security is important during execution as well as in the planning stages. Science is hard and many things will not work out the first time or two (or three, etc.). Plans and schedules are not (primarily) for the purpose of making it easier to blame the responsible person when things go wrong. The early recognition of mistakes and failures should be encouraged and congratulated as this will enable the team to get back on track most quickly. Admitting error is much less costly than trying to hide it.

4) Nearing completion

After the summer, when students return to classes, the project will experience a lull of two or three weeks. It is important to continue to hold weekly meetings to help get past this point and to settle the team in for the finishing kick. This lull may be even a bit longer if full-time students decide to take some summer vacation before heading back to classes. Instructors need to remember that a student's first priority is to their educational program and to whatever career path they have set out on, so some time for re-invigoration is very important.

4.1) Course or volunteer

It is easy to think the project is done, but is only getting started. Usually there will be lab work to complete, documentation to finish, and the Jamboree to prepare for. The most effective way to maintain student interest in the project is to make it worth their while. This will usually mean some course credit for their iGEM work, either through a specific iGEM course or through a Directed Studies or Project course. Encourage your students to register in such a course and encourage their home departments to recognize this effort.

4.2) Document to win

Apart from the poster and presentation iGEM projects must be fully documented on the wiki and BioBricks parts submitted. Wiki pages from past competitions are available on the web and reflect an amazing amount of talent and creativity. Because formatting and imaging as well as more interactive features are limited with the standard wiki formatting, teams may want to enhance their wikis with advanced HTML scripts.

Winning wikis contain well-formatted pages with many interesting images. The main page should briefly describe the project, the institution, the home city, sponsors, etc. Other pages can include more detailed descriptions and photos of the team and its members. It is good to include actual photos of the team at work and at play here; the Team Manager may also want to take on the role of documenting (and blogging about?) team activities. The Project details page documents the ideas, relevant references and explains basic concepts of the project. A modeling page can include formulae and modeling results along with source code for simulation. A parts page could include an overview of BioBrick parts for the project, including their design, construction and characterization. Full parts descriptions should be documented in BioBricks though judges may only look at the "favorite" parts. Colorful, well-designed images which clearly convey the important information are the goal for these pages.

Daily wet lab progress is to be documented in the Notebook pages. This may contain detailed information and act as an electronic lab notebook or it may be diary-like summaries of lab work. While we prefer a more detailed approach, it is not clear that this is important to the judges. The standard wiki comes with a calendar-like notebook, which is minimally useful. Many groups replace it with summary pages but many enhance it to provided better browsing capabilities (e.g. day-by-day flipping, project or researcher cross-references, etc.) Some groups include scans or gels and other such machine-generated raw data, while others do not.

Above all the wiki must be clear, attractively-formatted, easy to navigate and complete.

4.3) Organizing the presentations

Presentation teams are generally fairly small, generally 3 to 5 team members when all members speak English. Presenting your research is an important part of the scientific and engineering enterprise, so being on the presentation team is a valuable enhancement to the team member's experience. However, it will

require considerable extra work. Not only are presenters required to really know the project (or at least their part) thoroughly, they must be able to communicate it clearly and speak with authority. This is one of the most visible aspects of the entire competition and it is easy to be judged harshly. A typical presenter will require 12 hours of team practice and at least as much individual practice in order to nail their portion. The reason for this is that presentations are only 20 minutes, so there is no time to hesitate or stumble. Speaking quickly but clearly and correctly with confidence and authority requires a lot of rehearsal; longer talks are actually easier, in general.

The presentation should include the following:

- present the team, institution (maybe city and country)
- outline the reason the project is important,
- discuss the basic background science,
- describe the approach to solving the problem,
- present the model and its predictions,
- describe BioBrick parts made, sequenced, submitted and characterized,
- describe assays and results
- draw conclusions of what worked and what didn't
- talk about future plans
- thanks advisors and instructors
- thank financial supporters
- all in about 20 – 30 slides (at one minute or less per slide)

4.4) Poster

Posters are also an important part of the competition and previous posters should be examined for ideas on producing successful posters.

4.5) Team meetings and Focus-group meetings

As students return to classes, it can be very difficult to maintain regular meeting schedules. Most teams begin planning and preparing their Presentations and Posters during this time period. This is unfortunate as many students do not have enough free time to easily contribute to the project during the Fall. As mentioned previously, having students register in a class to allow them to get credit for their iGEM work will ensure they have some available to continue working on completing the project.

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5) The iGEM Jamboree (and after)

5.1) Publicity

Before leaving for the Jamboree, inform your various news agencies that your team has been working hard and is ready to compete. Not only will this raise local interest and team spirits, judges are impressed by team efforts to promote Synthetic Biology and iGEM.

5.2) Organizing – working the program

As with any conference, download and read the program and any abstracts before you get to the Jamboree. As a team, you should plan to look in on other teams' presentations and posters to use the Jamboree as a learning experience. Preparation for attending the Jamboree begins a few weeks prior when wikis are frozen. At this point the team should gather for a few hours to review what other teams have accomplished and to

determine whether any last minute changes to the Presentation or Poster need to be incorporated.

5.3) Practice talk

Upon arriving at the Jamboree, practice times are setup for the Friday night preceding the next day's competition. This will give team members a chance to practice in a room like the one they will actually use and, most importantly, someplace outside their comfort zone. Try to keep the tone of the presentation relaxed but serious. Minimize anxiety by being polite to other teams, who may be running a little late. Be kind and considerate. Feel free to sit in on other teams' practice talks but be appreciative and respectful that they are likely as anxious as you are. Your team should try to convey that they are ambassadors of good will and interested in others' success as much as their own. Be supportive.

5.4) Attending other talks

Team members should try to take in a fairly wide variety of other talks, both within and outside their stream, to enhance the iGEM learning experience. Certainly attend as many of the "big school" talks as possible, but try to take in a few of the lesser-known schools' efforts as well. Try to think of questions to ask the presenters. Culture your curiosity about other teams' work and frame your questions from curiosity rather than from a challenging perspective. Don't try to make others look bad.

5.5) Viewing other posters

Everybody likes to have others express interest in what they are doing. So the team should make an organized effort to visit a large number of posters and talk to team members there about their project and their iGEM experience. In addition to enjoying the Jamboree more, this will enhance the learning experience.

5.6) Team presentation

Arrive at the presentation room on time and be prepared to setup for your presentation quickly. Each team needs to bring its own computer and remote presentation device or laser pointer but the Jamboree provides the projector and sound, along with technical support. The key technical consideration in public presentations is to minimize surprises. Run the presentation of known hardware with known software, whenever possible. Bring more than one copy of the presentation (and possibly more than one presentation computer) to the talk. Be prepared for any equipment failure.

5.7) Finals

If you are fortunate enough to make it into the finals presentations, the only thing to remember is DON'T PANIC! You will be presenting your talk in front of a very large group of 600 to 1,000 people and you will be being judged by everyone present, so some nervousness is to be expected. Stick to your training and remember that you rehearsed for this, so just give your presentation as always and you'll be fine. Beyond that, the selection of the final winners is a mystery, so don't worry about it.

5.8) Debriefing initial impressions

Immediately after the Jamboree begin to collect immediate impressions from your team about how it went. Either on the plane ride home, in the airport or over breakfast the next day try to collect some initial ideas of what worked and what didn't and what can be improved next time. Collecting these ideas while they are fresh is crucial to annual improvement. Don't just talk and listen though, write them down and include them in your final report.

5.9) Post-Jamboree

So the Jamboree is over and you have returned home. You may think your work is done for a few months, but successful iGEM teams get to work almost immediately on the next year. As soon as possible, write a final report on your achievements for your sponsors, thanking them and discussing next year's plans. Immediately contact your news agencies to report on your success and strike up interest in the next team. Plan a celebratory gathering and the kick-off Open House to help recruit the next team.

5.10) Detailed debriefing

Team members should review all finalists' (and many Gold medal winners') projects from the iGEM results page in detail. Ideally, a number of team members will conduct this review, though the Team instructors may have to do the majority of the work as final exam time will be fast approaching. Review all team wiki's, their presentations and posters, and try to determine the winning criteria. This will be very difficult, but informative. If the team has proposed hypotheses as to why some teams did very well, try to collect objective statistics to evaluate these ideas. Although arduous and time-consuming, this will help the next year's team considerably.