Syllabus
IPRO 302
Spring 2007

Nick Menhart
menhart@iit.edu

Synthetic Biology?

Synthetic biology is an emerging discipline concerned with creating life from scratch, or designing and modifying it to specification in a way that is not found in nature. To distinguish it from simple molecular biology (i.e. "cloning"), this discipline involves an appreciation of the *systems* that make up life, rather than the *components*. A car is made up of its parts, but is more than their sum… an understanding of how fuel injectors and shock absorbers and windshield wipers etc. etc. work do not really convey what an automobile is, or how these parts work in unison to creates something that can take you to the movies. Rather, we need to understand the system that these components form.

Basic molecular biology has until this point developed the tools to work with individual genetic components – genes. But something fundamentally different happened when many genes interact together as a system, and a good argument can be made that this is exactly what life is. There is very little difference in a person and the same person immediately after death – all the cellular components and biomolecules are still there. Yet the system has been turned off. This is what we seek – to understand the extra something that arises when these individual pieces function as a system. Synthetic biology seeks to approach this task by designing and building such biological systems – sometimes called genetic circuits – form the bottom up. While we do not have the resources or training to produce a completely synthetic lifeform, we can do some substantial tinkering.

Returning to the car analogy, we do not aim to simply put a new set of wheels on, or painting it – or even turbocharge it. That akin to standard genetic engineering, - adding or removing one or a few genes ,and it still leaves us with fundamentally the same car, albeit pimped a bit. But remove the engine, put in a fuel cell and an electric motor – it is something different perhaps. Or put on wings and a propeller, and you have something even more fundamentally different. With the simplest living systems vastly more complicated that a car, the possibilities are very broad.

Aims

This class, being an IPRO, has two sets of objectives. The first relates to the specific project, and the second set is general IPRO goals. To be successful, we must all make progress toward both sets.

Specific Project Aims

This project has the following primary project aim:

The production of a novel, flashy, and aesthetically innovative engineered organisms.

You will all be working toward this aim in some fashion. The scientific inspiration for this project is provided a demonstration of the production of "flashing" bacteria (*Nature* **403:**335 2000) as well as theoretical analysis suggesting that coordinated flashing may make this behavior observable on a macroscopic scale (*PNAS* **99:**5988 2002). This raises the potential to move this strategy to multi-cellular organisms. In particular, we are working under approval in the zebrafish organism. In order to achieve these aims, we will be developing skills toward the following more limited project aims:

1. development of gene manipulation skills to achieve the primary aim
2. development of computational and mathematical models of pathways function to facilitate design of appropriate genetic elements
3. evaluation and consideration of the literature and techniques of the day, to determine how this project can be expanded and modified to develop ever more intriguing targets.
4. development of fish husbandry techniques, feeding, cleaning, breeding, raising.

General IPRO Aims

There are a whole host of IPRO objective set forth in a comprehensive IPRO syllabus. The most important general IPRO objectives are the development of

1. team work skills
2. project management skills
3. peer evaluation skills

These will all be addressed by the administrative structure of this project, as detailed below. As well, this is a continuing IPRO, and the aims of each semester's team must take into account the progress and problems of the previous semester's team.

Expectations

Every team member must contribute in some significant fashion to this project. Major, conscientious effort will earn you a B, which I expect will be the median grade. To earn an A, exceptional contributions are required. Conversely, trivial or perfunctory contributions will yield a C. I expect that you will contribute ~9-10 hours per week to this class. That means ~9 (i.e. 3 outside hours per credit hour) hours a week *above* the regular meeting times. Those of you hoping for an A can either expect to expand upon that, or be extraordinarily talented and efficient. As an example, the performance level expected for each letter grade are illustrated below:

A

innovative development of team goals to push the scope and vision of the project forward in realizable directions
consistent excellence in task performance
significant contribution to both product and process goals
personnel development, assisting others in their team tasks

B

completion of all team tasks in a thorough fashion.
development of team goals and team plan
occasional excellence in task performance

C

showing up to all meetings
completion of all assigned tasks.

although I do not hope or expect to issue such grades, the following possibilities also exist:

D

regular but imperfect meeting attendance
completion of some but not all tasks in a routine or perfunctory fashion

E

minimal participation in project tasks
submission of incomplete tasks
irregular meeting attendance

Actions and Administration

Faculty role

My role as lead faculty is not to run the team, but rather to act as a consultant to help you achieve the overarching primary team goals set forth above. An important aspect of the IPRO program is that you arte allowed to – indeed expected to – become self guided and self-motivated. The team is largely responsible for the conduct of the project. I will also be acting as a mediator in compiling peer evaluation, and in adding my own faculty evaluation for course grades.

Team structure

We will develop a team structure. This can take any form, but to satisfy IPRO requirements must minimally include

- a team leader
- a IPRO liaison officer

The team leader will be the "CEO" of the team, and be the focal point through which administrative matters willbe regulated. This does not mean that this individual will *control* the team. Rather, this is an office occupied by an individual, and that office has executive authority to codify and disseminate team actions. Subordinate administrative structure is to be determined by the team as appropriate to achieve team goals. The team will develop protocols to fill various roles as one of its first tasks.

Team IPRO liaison is some person, who may or may not be the team leader, that is charged with being the first point of contact for IPRO office personnel with this team. Other possible administrative entities include:

- sub-team leaders for various thrusts
- team secretary,
- IPRO deliverables officer
- coordinator
- IPRO day coordinator.

Meetings

The team will have regularly scheduled meetings, at least weekly. Initially meeting times are set by the IPRO office; this may be changed by the team to achieve its goals, but the team will in all cases meet as a whole at least once a week. Other meetings of smaller team components may substitute or extend from the second meeting time; however it is expected that each team member will participate in 2 - 3 hours of organized meeting per week. On a triweekly basis, one full team meeting will be at least partly devoted to peer evaluation discussions as outlined below.

Regular performance

In order to maintain performance objectives, and to satisfy grading requirements of the IPRO program, we will be implementing regular peer evaluation sessions. On a tri-weekly iteration cycle, you will all be required to present your progress to the rest of the team and they will evaluate your efforts. There is a specific evaluation template that will be used for this purpose to ensure uniformity and fairness in this process. It is crucial that you have something to report on a regular basis, so get busy…

Progress toward the project goals

The vast majority of the actual work of this course takes place outside of the regularly schedules meeting times. This aspect is the most nebulous, but the most important day-today activity. It is the most important, since such progress is the only metric we have to measuring whether we as a team are being successful. On a personal level, it is also important, since it is how your peers are going to judge whether you are contributing to the team, or being an anchor.

However it is also nebulous, since there are many ways to contribute to the team. This semester, I think we should serious focus on getting the fish work going in the lab – both learning how to breed and clone into these fish; and construction of our version 0.5 gene transfer targets for the fish genetics modifications.. But there are other worthwhile tasks

- Design of future enhancements and genetic targets – what CAN we do with this idea.
- Administrative tasks – record keeping, archive organization, IPRO day etc.
- Computational development – we have a great MATLAB bacterial simulator – can we modify this to reflect multicellularity?

I expect that everyone will contribute substantial to several aspects – some crucial lab work, and several other tasks. The details of exactly what you do will be up to you, and the team. Find some thing you are good at and enjoy, and run with it.

Website

The team will develop an website to:

- maintain a record of its activities and work product
- develop an exposition of its mission aimed at the general academic audience

IPRO deliverables

There are a number of IPRO program deliverables that are separate from the work product of this project. These are set out in the IPRO reporting system, http://iproprs.iit.edu, and must be adequately dealt with by the team. Major items and include the midterm and final project reports, the website, and the final presentation.

Grading

Your grade will assigned by faculty (25%) and peer (75%) assessment. We will be monitoring this on a tri-weekly cycle. In each cycle, you will all be presenting brief summary of your specific accomplishments orally to the rest of the team. These will be discussed by the team at the subsequent meeting, and then all team members will grade each other on a "Fortune 500" C/M/O scale of **C**oasting, **M**eeting goals, or **O**utstanding. Typically the lowest rung on this scale would go by "Unsatisfactory" or "Goal for improvement", but I have renamed it to emphasize that this level of performance warrants a grade of C – or lower. I will compile this feedback anonymously and return it to each team member.

Remember – this is a *team* project, not a compendium of individual efforts. To do well, you must not only accomplish good work, but you must communicate this to your peers – most immediately your team members, and at the end of the semester, at IPRO day to the rest of the class and the rest of the university. Eventually, perhaps, at a med-school interview. Or your grandmother, or anyone else you are trying to impress.

This is probably the most important thing you can learn in this experience: those who present themselves well, even if actually performing substandard work do better than those who excel in their work, but are unable to communicate their accomplishments. It may seem cynical, but that's the way it is, so get used to it. Of course, the best-case scenario is to do great work *and* present it well… something I hope all of you accomplish this semester.

Your grade will be assigned based upon the cumulative record of these evaluations, as well as the following other two factors:

50% tri-weekly evaluations

I will convert the **C**/**M**/**O** evaluations to a letter grade on a curve determined by the spread in the peer evaluations. Typically, you want to have more **O**s than **C**s for a B, and more **O**s than **M**s for an A.

25% final peer evaluation

This is a more detailed form, supplied by the IPRO office, and typically works with 20-30 rating categories on a 100 point scale (and is and evolving document that changes each term, it seems). I will also be converting this to a letter grade, and from there to the 25% contribution. To achieve an A you typically need to score in the upper quarter.

25% faculty evaluation

This will also be given as a letter grade, and then converted to a numerical score based on the scheme shown below. I will be considering the same factors as the rest of the team, *as well as how you perform on these administrative tasks – i.e. how well you do this grading*. If you give everyone O's (or C's) that is probably unwarranted, and is evidence of poor performance on this evaluation task. So it is in your best interest to actually put some thought into it and evaluate people fairly and accurately. It is often a difficult thing to evaluate people, especially your peers. But in any professional setting, this is a large part of how it is done. So start training yourself to do it well.

Your evaluation grades will be converted to a letter grade by use of the following scheme, depending on whether this is your first or second IPRO:

IPRO:	2	1
A	85%	80%
B	70%	65%
C	60%	55%
D	50%	45%

Talk to the returning team members to understand how it works. I find that peer evaluation is very accurate when done properly: the project is so large and complex, that no one person can know everything everyone is doing. But if you are performing well, it is almost inevitable that several members of the team will be aware of this, and you will do well. Conversely, it is very hard to slack off and hide from everyone – and typically your peers are even harsher that the faculty on those who try.

To be successful, this project must accomplish two things: you must all grow professionally, and we must make measurable progress toward the primary project goal. This is an exciting task, and offers a great opportunity to accomplish both of these objectives.