Responsible Research and Innovation in Synthetic Biology

Course developed by:
MIT iGEM Team 2018
## Course Information

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<tr>
<th><strong>Course Name</strong></th>
<th>Responsible Research and Innovation in Synthetic Biology</th>
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<tr>
<td><strong>Hours of Guided Learning</strong></td>
<td>8</td>
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<tr>
<td><strong>No. of Modules</strong></td>
<td>4</td>
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<td><strong>Targeted grade level</strong></td>
<td>Juniors and Seniors in high school; College students</td>
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<td><strong>Acknowledgements</strong></td>
<td>RRI Tools, ESPRC, BioBuilders program</td>
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<td><strong>To be taught in conjunction with</strong></td>
<td>AP Biology, BioBuilders program</td>
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Course Description:

This course is an optional addition to synthetic biology courses that already exist. It does not hope to replace these courses, but rather augment them by providing a fuller picture of synthetic biology and its intersections with the real world. The course consists of 4 one-hour modules following the AREA guidelines: Anticipate, Reflect, Engage, and Act. Each module consists of a lecture section, an individual activity section and a group activity section.

The short lecture sections will involve dissemination of information that will teach students the Responsible Research and Innovation (RRI) framework: how to anticipate potential opportunities of a research project, what considerations must be reflected upon before diving into commercialization of a product, how to engage with the public and relevant stakeholders in order to gain a deeper insight into the impact of the technology, and finally how can we, as researchers, scientists, teachers and policymakers, act appropriately in order to ensure that research is done responsibly.

The individual activity sections will vary from reading case studies and filling out Stakeholder/Value matrices to writing policy drafts as policymakers in order to amend laws regulating biotechnology and synthetic biology.

The group activity sections will range from group discussions for carrying out SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis to role-playing a possible dialogue/engagement between a researcher and a stakeholder affected by the researcher’s technology.

The course aims to foster a habit of healthy discourse in students and emphasizes critical thinking as a major tool to navigate the political, ethical, economic, and societal implications of all our actions.

Philosophy:

The course was developed as a result of the iGEM MIT team delving into iGEM Human Practices literature and realizing that currently used synthetic biology curriculums do not include enough about the impact of research and technological advancements on society. To remove public mistrust of new synthetic advancements, it’s very important to cultivate an environment that promotes responsible research within the scientific community.

We believe that with the rise of community labs (fab labs), online synthetic biology learning resources, and various lab-in-a-box platforms, pretty much anyone can make some pretty
awesome (or harmful) things right in their backyard. This makes it all the more important to educate people about responsible science.

When talking about gene drives, a technology that can cause a selected trait to be spread to an entire population of species due to biased inheritance, Jennifer Kahn said it in her TED talk “..to genetically engineer an organism and include a gene drive, is something that basically any lab in the world can do. An undergraduate can do it. A talented high schooler with some equipment can do it.”

The current system relies on the assumption that all scientists will act responsibly. But with recent incidents such as the one involving Aaron Traywick, a biohacker who injected himself with a self-made herpes treatment, we know that this assumption is not always true. We, therefore, developed this curriculum to make that assumption into a reality, where the scientific community of tomorrow (e.g. people studying synthetic biology today, such as yourself) has a more structured mentality of doing science responsibly.

In order to do so, we developed this curriculum with the following aims:
- Foster critical thinking by encouraging students to constantly reflect and engage
- Promote a collaborative environment by demonstrating how different actors in society come together to create productive and mutually beneficial
- Cultivate habits of engaging in meaningful and constructive dialogues and managing confrontational situations in a calm and rational manner
- Provide opportunities to explore the various facets of synthetic biology which includes not only doing science but also communicating and justifying science
- Produce responsible citizens who are aware of the political, ethical, economic, and societal implications of their actions
- Give students the tools necessary to further spread these ideas in an effective and systematic manner
Pre-requisites:

Students taking this course will be expected to know the basics of synthetic biology. They must have previously taken or must be currently enrolled in a synthetic biology course. This course assumes that students will have basic biological laboratory knowledge and know some amount of detail regarding research methods employed in synthetic biology.

Learner Objectives:

The learner objectives of this course are aligned with the learning goals of the RRI science education guidelines, which includes being able to:

➢ relate research and innovation processes in synthetic biology to the role of responsibility in these processes;
➢ discuss the relationship between science, research, innovation, and society;
➢ identify the potential impact of science/research/innovation on individuals, groups, or society as a whole.
## Syllabus Content:

### Module 1: Anticipate

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<th>Group Activities</th>
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| Describing and analysing the impacts, intended or otherwise, (for example economic, social, environmental) that might arise. This does not seek to predict but rather to support an exploration of possible impacts and implications that may otherwise remain uncovered and little discussed | a. Lab Health and Safety Worksheet  
b. Impact Mind-Map | a. Case Study 1 (MIT)  
b. Group discussion of SWOT analysis |

### Module 2: Reflect

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| Reflecting on the purposes of, motivations for, and potential implications of the research and the associated uncertainties, areas of ignorance, assumptions, questions, dilemmas, and social transformations the research may bring | a. Case Study 2 (LYON)  
b. Stakeholder/Value Matrix | a. Group discussion about Stakeholder/Value Matrix  
b. Demonstration: Video |
# Module 3: Engage

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<td>Opening up discussion of the researchers’ visions, impacts and questionings of the research or intended products to broader deliberation, dialogue, engagement, and debate in an inclusive way</td>
<td>a. Questions to ask identified stakeholders</td>
<td>a. Role-play dialogue between researchers and stakeholders for Case Study 2 (LYON)</td>
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<td>b. Case study of public engagement methods</td>
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# Module 4: Act

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<td>Using these processes to influence the direction of the research and innovation process</td>
<td>a. Read through Open Access Checklist</td>
<td>a. Brainstorming different project ideas, and then responding to different/proposed forces</td>
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<td>b. Policy draft</td>
<td>b. Discussion about science education</td>
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Teaching/Learning Resources/Attributions:

1. AREA Guidelines - [https://epsrc.ukri.org/research/framework/area/](https://epsrc.ukri.org/research/framework/area/)
2. RRI Tools - [https://www.rri-tools.eu/](https://www.rri-tools.eu/)
3. iGEMmers Guide to the Future (stakeholder value matrix/SWOT analysis) - [https://live.flatland.agency/12290417/rathenau-igem/](https://live.flatland.agency/12290417/rathenau-igem/)
4. Jennifer Kahn’s TED talk on Gene Drives- Video Demonstration- [https://www.ted.com/talks/jennifer_kahn_gene_editing_can_now_change_an_entire_species_forever](https://www.ted.com/talks/jennifer_kahn_gene_editing_can_now_change_an_entire_species_forever)
7. Example of Class Handout (tested in a BioBuilders class), can be found on our wiki