

## **Ethics and Policy in Synthetic Biology: The Development and Testing of a Massive Open Online Course**

Debra Mathews, Assistant Professor, Johns Hopkins University

### **Introduction**

In 2011, Stanford's Sebastian Thrun held an open online version of his popular course, "Introduction to Artificial Intelligence" – 160,000 people, internationally, took that course. Such massive open online courses (MOOCs) quickly became both pervasive and incredibly popular<sup>i</sup>. To date, only a handful of MOOCs are available on bioethics, and of these, none is directed at scientists, themselves. At the same time, there is increasing interest in training basic scientists not just in research integrity (e.g., do not falsify data), but also in broader social implications of science, driven in the US by recent revisions to NIH and NSF requirements. Even in the context of a US university, opportunities for ethics and policy training for basic scientists related directly to the work they do can be difficult to find and access. Outside an academic setting, for individuals doing science in industry or community labs, it is arguably even more difficult. MOOCs might be a useful way to increase access to high quality training in the US and internationally.

In the case of synthetic biology, in particular, ethics and policy issues are an important and growing area of concern. One of the main concerns raised for many by synbio is dual-use: the development of knowledge and technologies that can be used both for good and nefarious purposes. Dual-use issues are rarely addressed with basic scientists, despite increasing concerns about bioterrorism<sup>ii</sup>. Furthermore, education on this topic is repeatedly cited as an important component to addressing security risks related to advances in the life sciences<sup>8,iii</sup>. This connection to dual use concerns and the importance of education is further highlighted by the FBI's interest in synthetic biology research, including at universities and in DIY labs. Dual-use and biosafety concerns have been part of the field from its beginnings in recombinant DNA technology in the 1970s<sup>iv</sup>, though at the time, biohazards were of much greater concern than bioterrorism. Beyond dual-use and biosafety concerns, there are also questions about ownership of modified or new organisms, and less tangible concerns about the meaning of modifying and creating life. Basic scientists rarely in their training and careers have the opportunity to engage with these questions.

### **A SynBio MOOC**

I am currently developing a MOOC on the ethics and policy issues related to synthetic biology, through which I will also test different assessment methods, focused on assessing ethical analysis in the MOOC context. This MOOC will be based in part on lectures I have given over the last six years in the Build-A-Genome (BAG) course, designed by Dr. Jef Boeke, a synthetic biologist formerly at Johns Hopkins, and now at New York University. The course will also draw on ongoing research with Dr. Boeke and others on a set of projects related to the development of a strain of *Saccharomyces cerevisiae* with an entirely synthetic genome. Work with these projects include research on governance structures in academia, industry and DIY labs, and international stakeholder engagement and deliberative meetings about the implications of the Sc2.0 project and synbio more broadly.

The course will begin with an introduction to the science, for those who are not members of the synthetic biology community. The course will then move on to the ethical issues raised by synthetic biology (e.g., dual-use, biosafety and intellectual property issues), and continue to an

overview of current national and international policy relevant to synthetic biology, as well as current and evolving governance structures within synthetic biology.

Course content will be delivered primarily through short (8-12 min) organized into weekly course sessions. Each week will require 2-3 hours of screen and independent work time, but can be completed at the learner's own pace. In addition to watching and working with video and animation modules, learners will also have an opportunity to create content through, for example, participation in online forums on the Coursera platform, and development of their final collaborative project. In these forums, learners are able to ask questions, and vote up or down others' questions, allowing the best questions of the greatest interest to rise to the top. New modules and activities can then be created in response to these questions. Content generation by learners is a strength of MOOCs, allowing for wide-ranging interactions between individuals with very different backgrounds and ways of thinking<sup>v, vi</sup>. In the synbio context, for example, how a particular culture or government views synbio may not be accessible to the instructor or other learners (e.g., due to language barriers), but will be brought to the course by individual learners. These forums can serve as opportunities for both learning and assessment, wherein learning happens through dialogue, and the initiation of and participation in that dialogue can be captured as metrics of learning<sup>18</sup>.

## Conclusion

This course would be one of only a handful of bioethics MOOCs, and perhaps the only one aimed at basic science researchers. The dearth of such training generally, combined with the desire for such training, suggests that this course could serve the needs of large numbers of local, national, and international scientists regardless of ability to pay (acknowledging that the need for a computer and broadband access is not an insignificant barrier). Within academic institutions, the course could be used not only in individual science courses under a blended learning model, but also for training of basic scientists more generally, and potentially to fulfill the NIH and NSF training grant requirements. For those working in laboratories without access to bioethics colleagues or in countries lacking bioethics capacity, this could also be tremendously useful. Outside academic institutions, the course could also be used as required or optional training for those working in community and academic molecular and cell biology labs. As this kind of training usually only occurs within academic institutions, this course may be particularly important for the DIYbio community, which largely exists outside any academic institution. This course will bridge that divide and provide access to high quality, important training, which can evolve along with the science. Further, this course would provide not only a valuable learning opportunity, but also a trove of rich content that will live on and can be accessed indefinitely.

---

<sup>i</sup> <http://www.nytimes.com/2012/11/04/education/edlife/massive-open-online-courses-are-multiplying-at-a-rapid-pace.html?pagewanted=all>

<sup>ii</sup> National Research Council. *Challenges and Opportunities for Education About Dual Use Issues in the Life Sciences*. Washington, DC: The National Academies Press, 2010.

<sup>iii</sup> E.g., see <http://www.opbw.org>, Final Declaration of Second Review Conference.

<sup>iv</sup> Berg et al. Summary statement of the Asilomar conference on recombinant DNA molecules. *Proc Natl Acad Sci USA* (1975) vol. 72 (6) pp. 1981-4.

<sup>v</sup> Clougherty Jr and Popova. *Crowdsourcing to Assess MOOCs: A Position Paper*. MOOCs FORUM (2013). 1(1): 10-13.

<sup>vi</sup> Hong and Page. *Groups of diverse problem solvers can outperform groups of high-ability problem solvers*. *Proc Natl Acad Sci USA* (2004) 101(46): 16385-9.