Selected Issues in Depth - Genomics and Synthetic Biology/Microorganisms/Biofuels

Description

Part of Unit 2 of the Course on Genomics Ethics and Society, this section features video clips from talks by Dr. John Glass and Dr. Tim Devarenne on the ethics of synthetic biology and using transgentic organisms to create biofuels.

Body

In this "Selected Issues in Depth" section we look at two issues. First, Dr John Glass, from the J. Craig Venter Institute, talks about key research in synthetic biology, the creation of synthetic organisms, and the contribution this research might make to medicine. He also considers some ethical and policy issues that will be central to future work in synthetic biology - and to the perception of future work in synthetic biology. Here's a link to Dr Glass's page at JCVI: http://www.jcvi.org/cms/about/bios/jglass.

Second, Dr Tim Devarenne of Texas A&M University talks about the potential for using transgenic organisms to produce biofuels. (Here's a link to his lab page: http://devarennelab.tamu.edu/).

Our first speaker, then, is Dr John Glass. Dr Glass begins our discussion of synthetic biology by outlining how DNA is used to understand cellular life. His argument is that if we can understand what factors are important in the construction and maintenance of what's called "minimal life," than we can use this information, ultimately, to contribute to improved health outcomes for humans. The minimal genome, as Dr. Glass explains, is the genome of an organism with only those genes essential for life in a laboratory setting. Without any one of the minimal genes the organism will die. To illustrate this concept Dr. Glass introduces *Mycoplasma mycoides* and explains how transposable elements can be used to identify which genes are essential and which are not in the *M. mycoides* genome.

Now that we have a better understanding of what a minimal genome is, Dr. Glass discusses how his team of researchers at the J. Craig Venter Institute transformed *Mycoplasma mycoides* into *Mycoplasma laboratorium* and in the process created the first wholly synthetic genome. Dr. Glass provides a very detailed explanation of synthetic genomics and the processes involved in this landmark accomplishment. Take a moment and consider what the ramifications of this accomplishment are.

Clearly, creating a synthetic genome is tremendous accomplishment, but what technologies have laid the ground work for such discoveries, and where will we be in the next ten years? Dr. Glass highlights the importance of emerging technologies in sequencing, commonly termed Next Generation Sequencing (NGS) and shows that the costs associated with sequencing have fallen so drastically that they no longer constitute a barrier to genomic inference. In the future, synthesizing genomic regions or whole genomes will be so cost-effective that a researcher can send off a sequence for synthesis, have it returned in only a couple of days, and boot it up in an organism to see the results.

Synthetic genomics is a powerful tool that allows researchers to better understand the constituent parts of cellular life. Another example of synthetic biology is using genomics to rapidly produce viral vaccines. Dr. Glass illustrates the utility of this approach by showing how synthetic biology is being used by the Venter Institute to create flu vaccines.

With all of the discussion on the technological advances and the resulting genomic engineering of life, Dr. Glass takes a moment to discuss how scientists should do a better job of educating the public about their work in synthetic biology. He also points out that it's important to consider the ethical aspects of creating life *de novo*.

Pay attention in particular to the last slide in this video, and to its summing-up of some of the governance concerns related to synthetic biology.

The concepts of naturalness and playing God are commonly voiced arguments against genomic technologies. Dr. Glass argues that transgenic and genomic scientists should be able to discuss these concepts with the general public. This video expands on the previous clip, further identifying ways in which researchers and stakeholders can interact to develop acceptable public policy regarding genomic technologies and their outputs.

There are many legitimate concerns regarding the use and creation of synthetic organisms. For example, Dr. Glass cites possible uses of synthetic organisms in bioterrorism, as a cause of environmental harm, and the site of ethical and religious concerns. In closing, how, then, can synthetic biologists guarantee responsible use of this technology and provide a forum for debate about when and how such technology could or should be used?

BIOFUELS

Our second speaker is Dr Devarenne. Energy dependence is an important area of research worldwide, not only because of the economic importance of having a sustainable source of energy, but also with regard to global climate change. For this reason, many researchers have been searching for alternative sources of renewable energy. Dr. Devarenne begins his discussion of the genomics of biofuels by introducing *Botryococcus braunii*, a green algae capable of producing large quantities of petroleum. One of the interesting pieces of this video is the illuminating fact that very few of the algae species actually are transformable and thus conducive to biofuel production. Also, of the species that can be transformed, not all of them have genome sequences available.

Though algae are ideal for the production of biofuels, our limited genomic knowledge of the organism restricts the ability to fully develop and test transgenic modification. Tobacco (*Nicotiana tabacum*), on the other hand, is a genetic "model" organism that is easily transformable, and that allows researchers to test transgeneic modifications related to biofuel production. Dr. Deverenne does note, however, that we will likely never be able to grow enough of the crop for it to be a viable biofuel source.

Transgenic organisms - such as those used to produce biofuels - may have the potential to dramatically improve human wellbeing. Yet there are risks if this research is not regulated in terms of the context of the transgenic organism, its use, and the environment in which it is being raised. In the next clip, Dr. Devarenne briefly highlights some of the concerns raised by producing transgenic algae along the Gulf Coast of Texas. What kinds of problems do you see, if any, with the accidental release of transgenic organisms?

There are many organisms that either produce biofuel or can be converted into biofuel. Dr. Devarenne argues that algae are the most appropriate, given the reduced need for large quantities of agricultural land, their ability to produce high biomass, and the potential for them to produce high amounts of biofuel.

Lastly, from a climate change perspective, biofuels are generally more environmentally friendly when compared to fossil fuels (though there are some exceptions, as our readings for this week suggest). Burning fossil fuels releases stored CO_2 into the atmosphere, while plant based biofuels pull the CO_2 out of the atmosphere, and recycle it; it is used as energy without introducing any additional CO_2. This, of course, allows the persistent addition of CO_2 to the atmosphere to be greatly reduced.

Continue to Readings

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