Online Ethics Center
FOR ENGINEERING AND SCIENCE

Background

Description

Part of unit 3 of the Course on Genomics, Ethics, and Society, this section provides background information for the unit on genomics, ethics, and crops.

Body

GM Crops: Concerns, Values, and Consequences

This unit concerns the creation and use of GM crops. A discussion of GM crops first requires an understanding of what GM crops actually are. In general, a genetically modified (GM) or genetically engineered (GE) organism is the term used when the organism's genome has been altered directly in a laboratory setting. A gene from a related or different organism, the transgene, is inserted (or a gene is deleted) in a plant or animal to confer a desirable trait. While this outcome can often be accomplished by crossbreeding or genetic selection over time, modification of DNA in the laboratory can be a more efficient method.

In crops there are two primary approaches that are employed to integrate the transgene into an organism's genome: transfer via agrobacterium, or microprojectile bombardment. With either approach, the transgene is incorporated into the crop using cell or tissue samples and then the cells are regenerated into a whole plant, known as the *primary transformant*. The primary transformant now has the transgene incorporated fully into its genome and can be used to produce clones or seed crops where the resulting individual will have

the modified desired characteristics (phenotypes). For a brief overview of modification of crops using agrobacterium, see www.nepadbiosafety.net/subjects/biotechnology/plant-transformation-agro.

In a case where a nutrient is added to fortify a food, for example, the insertion of the gene that results in production of that nutrient in the cell is a much faster approach than other methods for generating the desired phenotype. When discussing crops, keep in mind that another method of producing new varieties of plants is to irradiate seeds. Exposure to x-rays causes damage (mutations) in the DNA of the seeds, and those mutations can be observed in the plant that develops from the seed, as well as its offspring. Typically, organisms modified in this manner have not been referred to as GM or GE organisms.

Debates about the creation and use of GM crops take a number of forms; and in different countries, very different concerns about GM crops have shaped public debate and policy. In this background section, we'll introduce some general social and ethical concerns about GM crops. In other parts of this unit, in our readings and "Selected Issues in Depth" sections, we'll also consider the diverse forms these debates have taken internationally. As well as the major debates about the production and use of GM crops, in the US there's also a related debate about the labeling of GM crops in foodstuffs. We won't be focusing on this here, but there are some relevant resources in the Additional Resources section.

Most generally, social and ethical debates about GM crops have two main forms: either they concern the intrinsic nature of the technology, or the consequences of deploying it. Concern about the intrinsic nature of the technology usually relates to its “unnaturalness,” whereas debates about the consequences of GM crops concern their purported effects (both positive and negative) on human health, social justice, or the environment. We’ll briefly outline the key issues at stake in each of these types of concerns.

1. The “Naturalness” Debate

We discussed concerns about the “unnaturalness” of genetic manipulations in both Units 1 & 2 of this course. These concerns return here. In fact, this worry recurs in virtually every area of genetic and genomics research (although it’s generally less prominent in discussions of medicine).

The basic claim here is that GM crops, or the processes that produce them, are *unnatural*, and that this unnaturalness is bad. To make sense of this claim requires some kind of definition of what naturalness/unnaturalness is, and why there's something wrong with it, or at least the kind manifested by GM crops. And this is difficult to do.

Let's begin with thinking about "naturalness". An obvious question here is why GM crops, or the practices that produce them, might be considered "unnatural" in ways that the practice of conventional selective plant breeding is not. Both are products of significant human intervention and influence, after all; but presumably someone who rejects GM crops on the grounds of their unnaturalness does not thereby want to reject all selective breeding of crops. One possible response might be to say that genetically modifying crops violates natural boundaries between species, and that the kinds of genetic changes involved in the production of GM crops could not happen in nature or by normal selective breeding. However, this isn't wholly correct; genes do transfer between species 'in nature' even without human intervention; a process called *horizontal gene transfer*.

Even if the argument that GM crop technology is unnatural in a way that's distinct from conventional selective breeding succeeds, the question remains as to why unnaturalness is bad. We value unnatural things all the time – such as vaccines and contraception. And the smallpox virus is natural, but that doesn't seem to be a reason for valuing it!

It may be that when scrutinized more closely, naturalness arguments here are really about consequences, and are not 'intrinsic' arguments at all. The worry might be that the more unnatural something or process is, the worse its consequences. We consider debates about consequences below.

The **Thompson and Hannah** reading (Week 1 in this unit) has further discussion of this issue.

2. The Impacts of GM Crops

The dominant method for evaluating whether any particular GM crop should be implemented in a particular place or nation is to calculate whether it increases yields or produces some other benefit (such as producing a human medicine) in a cost-effective way, without causing significant damage to human health, social justice or the environment (including nonhuman animals). This is a form of *cost-benefit*

analysis, an increasingly popular tool for conducting governmental policy-making, particularly with respect to GM crops.

However, every element of these judgments, whether positive or negative about GM crops, is widely contested. For instance, there are empirical debates about whether particular GM crops do in fact increase yields in a cost-effective way, or at least in a more cost-effective way than already available alternatives; and there are debates about whether GM crops are in some way risky or beneficial to human health; whether they create, intensify or diminish social justice problems; or whether they are harmful or beneficial to the environment.

2.1. GM Crops and Human Health

Some GM crops have been specifically designed to contribute to human health. Most well known among these are biofortified crops, in particular “Golden Rice” containing vitamin A, a vitamin to which some human populations lack good access. Where a GM crop can produce a targeted nutrient or medicine, it may be argued that it *improves* human health, and that other crops in the future could be even more successful at producing targeted nutrients or medicines (what are sometimes called ‘functional foods’). This view is defended by **Hansson and Joelsson**, one of the readings for Week 1 of this unit.

Critics, however, argue that there are alternative ways in which these nutritional needs can be provided for, that GM research diverts funding from more efficient ways of providing nutrients, and that GM crops such as golden rice pose other kinds of environmental problems. For a brief overview of the golden rice debate, see this NPR story from 2013:

http://www.npr.org/blogs/thesalt/2013/03/07/173611461/in-a-grain-of-golden-rice-a-world-of-controversy-over-gmo-foods.

A more general argument about human health is that GM crops help to increase or secure food supplies, by producing higher yields and allowing crops to grow in currently unproductive places or places that may become less productive owing to changing climate, since crops can be modified to better survive droughts, salinity, and pests. Improved food security, it’s argued, is particularly important, given increasing human populations and threats such as climate change (There is some discussion of this in the "Selected issues in Depth" section of this module.)

This argument is also controversial, however. Objections often focus on the claim that malnutrition, and lack of access to food resources, are not food supply issues, but rather political and economic problems. So, producing more food, without tackling these political and economic frameworks, will not necessarily improve human welfare (and, as Jepson suggests in the "Selected issues in Depth" section, may affect human communities in ways that decrease human welfare). Since GM crops are expensive and risky, it's argued, societies should focus on other ways of improving welfare. (See social justice arguments, below.)

It's also argued that some forms of GM crops protect human health by reducing the risk of exposure to pesticide. This perhaps is particularly true of BT crops, such as BT maize, which have been modified to express proteins that act as an insecticide for certain insects, but which are harmless to people, and which reduce the need for insecticidal spraying. (**Hansson and Joelsson** discuss this in more detail).

On the other hand, the consumption of GM crops is often opposed based on concerns for *risks* to human health. One worry is the possibility of particularly sensitive individuals having unexpected immune reactions to foods with altered genetic configurations (**Thompson and Hannah** discuss this, in the context of a tension between the interests of the many who could benefit from GM crops, versus the violation of the rights of the few who might unknowingly be exposed to allergens.)

More generally, it's sometimes suggested that the consumption of some or all foods containing GM ingredients raises the risk of serious human disease, including cancers. These debates require empirical evidence in order to be convincing. There does seem to be a risk of GM food containing allergens (this is something for which GM crops are always screened, though there's debate about how effective this screening is). But evidence at the current time does not support the view that, currently, widely consumed GM crops raise the risk of serious diseases such as cancers. Nonetheless, such concerns are widely expressed and are grounded in other widely shared concerns—for instance, that the empirical research into the health consequences of GM crops is inadequate, untrustworthy or otherwise unreliable. A recent study by Van Eenennaam and Young (https://www.animalsciencepublications.org/publications/jas/articles/92/10/4255?highlight=&search-result=1) attempted to address these concerns by evaluating 29 years of research related to genetically engineered animal feed and its impact on productivity and health.

2.2. GM Crops and Social Justice

One of the main reasons why, it's often argued, GM crops must be developed is that they will increase crop yield and food accessibility, particularly in poorer countries that lack the resources to grow enough affordable food for their increasing populations. However, many critics have claimed that the role of agribusinesses in the development of these crops, and infrastructural changes that have been, or might be, put in place in order to foster GM crops potentially or actually make the poor worse off, and undermine the security of family farms and farming communities. These critics contend that development of GM crops has come about in order to boost the profits of agribusiness, not to help farmers or the people they feed.

Concerns about how GM crops affect the poor and least advantaged are usually framed in terms of *social justice*, in particular *distributive* justice and *participative or procedural* justice. Distributive justice, as explained in the first unit, considers the fair distribution of benefits and burdens in societies; while participative justice considers whether consultation with all those affected is fair and meaningful. Food, and the labor required to produce food, are two such "benefits and burdens" usually at issue in these debates. Taking a social justice approach here means asking whether the production of food by the use of GM crops is fair to the poor and to the worst-off, and whether it benefits or disadvantages them; and whether they are meaningfully consulted about the introduction of GM crops.

One possible set of consequences that's been widely discussed in this context is whether the cultivation of GM crops will eventually, in certain locations, replace traditional agriculture, including much of the societal infrastructure that supports those traditions. GM crops that are herbicide resistant can require less management, and may therefore reduce demand for labor on farms, potentially decreasing rural employment and prompting a movement to urban areas. However, even if both these effects actually occur, there's still room for debate as to whether they are socially unjust. While there are instances where poor farmers simply cannot afford to purchase GM crops or cannot compete with larger farms growing GM crops, and so are forced to abandon farming altogether; on the other hand, small farmers may increase their yields, and this may have beneficial consequences for wider populations.

It's largely an empirical question whether growing GM crops benefits small farmers, especially in developing countries (although this requires agreement on what a benefit is), and any benefits may vary from location to location. A 2009 study by the International Food Policy Research Institute concluded that GM crops have produced some overall benefits for smaller, poorer farmers, but that the evidence is not yet conclusive. See here: http://www.ifpri.org/sites/default/files/publications/pv10.pdf A more recent review study, published in November 2014 in PLOS ONE, and widely reported in the international media, concluded that GM crops generally brought benefits to those farmers that used them, as well as having some other positive impacts. But again, of course, there will be controversies about these conclusions. (This paper by Klumper and Qaim can be found here: http://www.plosone.org/article/info:doi/10.1371/journal.pone.0111629)

Of course, small farmers are not the only ones affected by the introduction of GM crops; those who consume the crops and others within and outside the farming communities may also be impacted. So, a variety of social justice issues can be raised – **McAfee** discusses some of these issues in the reading "Beyond technoscience," for the second week of this unit.

2.3. GM Crops and the Environment

Some GM crops have been or are being developed, at least to some degree, with environmental benefits (alongside economic benefits) in view. For instance, some GM crops are being developed as biofuels, to reduce reliance on carbon dioxide-producing fossil fuels. Some require less fertilizer, increasing yield while reducing fertilizer run-off into rivers. Others are engineered to be pest resistant, leading to a much reduced use of insecticides (though some insects are developing resistance to these strains, which has been a problem in South Africa). **Hansson and Joelsson** develop a series of arguments defending the environmental usefulness of GM crops.

But nonetheless, persistent environmental concerns remain, concerning:

a. Loss of biodiversity: The most significant environmental worry concerns a potential loss of *biodiversity* if genes flow from a GM crop into the wild plant population through, for instance, pollination. (This issue is discussed in the reading by **Mercer and Wainwright** for this module, and by Jepson in her discussion of maize in Mexico.) Biodiversity can be defined in different ways, but one fairly typical definition is from the Convention on Biological Diversity:

> "the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems." (See here: http://www.cbd.int/convention/articles/default.shtml?a=cbd-02)

On some views, biodiversity, or wild biodiversity at least, is thought to be intrinsically valuable (valuable independently of its usefulness to humans) and that therefore it should be protected. But biodiversity may also be valued because it's an important source of *ecosystem services* – the useful things that ecosystems can do for people. One key service wild biodiversity can provide is to act as a gene pool for future cultivars. Imagine, for instance, that a new maize disease developed, to which current maize cultivars were vulnerable. The pool of genes in wild maize varieties would provide somewhere to seek a form of maize not vulnerable to the new disease. So, the concern about GM crops here is that if genes flow from GM populations into wild populations, these potentially useful genetic pools in wild plant populations may be lost. Here's a BBC news story focusing on this concern (not just about GM crops, but the loss of crop varieties in general) http://www.bbc.co.uk/news/science-environment-26382067

b. Increasing use of herbicide: One of the main ways in which crops have been engineered is to be tolerant of the herbicide glyphosate. Glyphosate-tolerant crops can be sprayed with glyphosate to kill weeds, without any harm to the crop. This development has led to an increase in the use of glyphosate (though it has also led to the decrease in the use of other herbicides more toxic to human beings). One impact of this is the decline of wild plants in crop fields that provided habitats for wild species. For instance, the decline in milkweed, a key food for monarch butterflies, may be partly due to the use of glyphosate; and the loss of milkweed seems to have led to a steep drop in the monarch butterfly population.

3. Conclusion

The debate over GM crops, and their effects on human health and wellbeing, social justice, and the environment is extremely complex, often depending on empirical evidence that is difficult to acquire, carried out in a matrix of competing values, and understood in different ways by different cultures. We encourage you to use the material in this unit to explore these debates in more depth.

Continue to Selected Issues in Depth

Rights

Use of Materials on the OEC

Resource Type

Instructor Materials

Topics

Emerging Technologies

Discipline(s)

Genetics and Genomics
Life and Environmental Sciences