The last supper? – Why new technologies are essential for feeding a growing world population

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Everyone needs it, sooner or later. Everyone has a preferred one. Everyone has something that he does not like.

I am talking about food.

All of us, rich or poor, tall or small, need food to feed our bodies and power our brains. Food is produced by farmers, who plant the seed and harvest the grain after one growing period. The process is not only determined by external factors like the climate, the soil and many other parameters, but also by the techniques and methods farmers use.

The world's population continues to grow steadily and will reach around 10 billion by 2050, as the UN states. But the arable area is not growing at the same pace. While forests are deforested to get more farmland, in other parts of the world fields become unusable because of the climate crisis. Wars, such as the recently started war in Ukraine, do not help ease the supply problem.

To be able to feed the world, innovative technologies are a major opportunity for increasing the yield in the existing farmland. Technologies under development are not only autonomous farming machines, which allow to work more efficient and save a lot of time, but also other emerging technologies such as cultured meat or CRISPR-Cas9 (hereafter abbreviated as CC9). In this article, we will shed a light on CRISPR-Cas9 and look at its challenges and advantages from a utilitarian ethics point of view.

First, let us try to understand what emerging technologies are in general. A Google search on the word “emerging” shows a definition from Oxford Languages, saying that the word is used to describe something that is coming into view and was formerly hidden. The “something” in this case is a new technology. As we learned in the “Ethics of Emerging Technologies” lecture, that was given at the Humanities and Arts department at the Technion - Israel Institute of Technology, the word “technology” originates from the Greek words “techne” and “logos,” the former meaning technical skill, and the latter meaning debate. A more formal definition was developed in a work from Rotolo et al., who name five criteria that must be considered, such as “radical novelty” or “uncertainty and ambiguity.” CRISPR-Cas9 fulfills those requirements, as will be shown later.

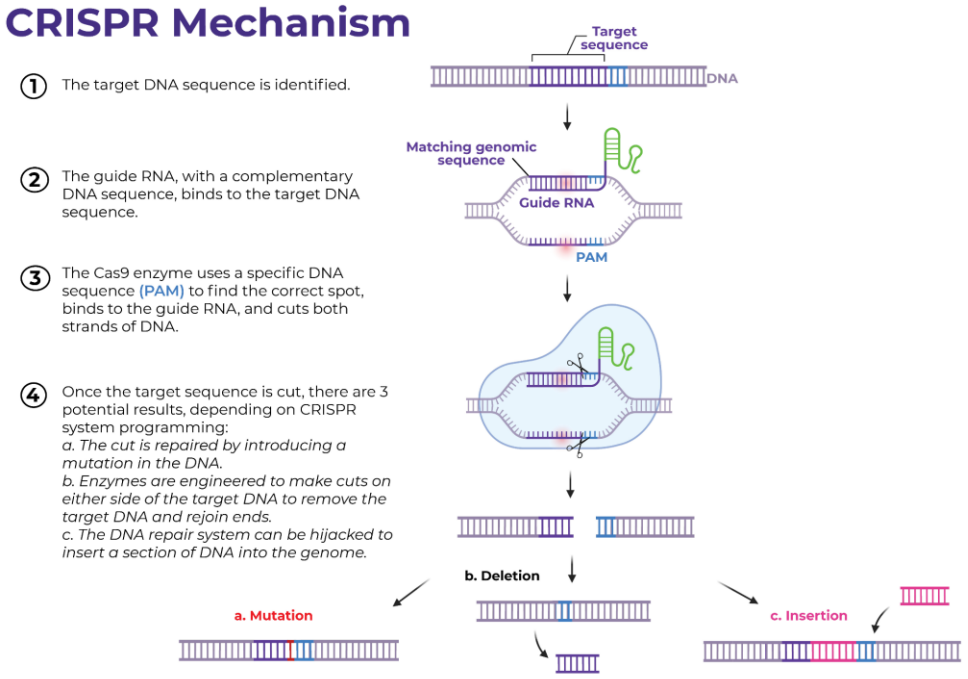
To correctly deal with it, we must understand what this technology does and how it works. We start with Clustered Regularly Interspaced Short Palindromic Repeats And CRISPR-associated protein 9, better known as CRISPR-Cas9. It is a process that was first detected in bacteria, which use it to defend themselves from viral infections. When a virus is successfully rejected, leftover pieces of the virus’ DNA are stored to allow defending against the virus later. These pieces are in the form of RNA (which is like DNA, but only one and not two strands), and work as guides to detect DNA that is the same. For a better understanding, Figure 1, taken from the University of Massachusetts Chan Medical School website, visualizes how the process works. So, when the virus is detected again, a special protein, Cas9, can eliminate the DNA by cutting the strands, destroying the stored information.

This bacterial defense mechanism is replicated in human DNA. The guide RNA can be artificially created to find the wanted gene, which can then be cut up, allowing the insertion of new DNA, mutation of existing DNA or deletion of parts of the DNA with extremely high accuracy. It can be used for a variety of purposes. Much of the discussion is raging around the therapy of illnesses, however, in this essay we focus on plant alteration. It does not take long to think about applications of this technology that are ethically demanding, but we will get back to this later.

After having a glimpse of what this technology does, let us see which concerns critics raise about its usage. We will not just blindly list different arguments, but we will roughly follow the guidelines from the third handout of the Ethics of Emerging Technologies lecture by Wessel Reijers to approach this case. Specifically, we focus on the utilitarian ethics approach which

is reputed to have been developed by Jeremy Bentham. The main question, in this case, is: “What is the good thing to do?”. We will analyze if it benefits sustainability and food security and if there are major drawbacks.

Figure 1: The CRISPR mechanism as shown by the UMASS Chan Medical School



CRISPR-Cas9 for plants and animals – a utilitarian view

On the one hand, CRISPR-Cas9 allows to speed up the breeding process, makes it much cheaper, increases the accuracy and is generally more efficient than comparable gene-editing techniques. For plants, it means that they can become tolerant against droughts, salty soils, and insects, and they can have higher yields, in a shorter amount of time. Also, this method is feasible for poor countries and companies, making the development of new plant strains more democratic.

That sounds good, doesn’t it?

Yes, but opponents also have reasonable arguments. Critics argue that it is not possible to fully relate the genome to the desired output yet as one genome is not only responsible for one single function but involved in different processes. Furthermore, it is not possible to ensure those plants do not harm the environment because unintended side effects appear later. Though, proponents of CC9 claim that random mutations of the genome are part of the evolutionary process and that already every plant is different to its predecessor.

As you can see, it is not easy to find a definitive answer. No one can tell how a plant strain will evolve in the future, and if it will develop unwanted properties. Thus, let us think of alternatives to secure the food supply and compare it to the advantages and disadvantages

of CRISPR-Cas9. A plant needs space to grow and develop roots, water, and nutrients (that they can only absorb in liquid form), and they must deal with external threats such as fungi. The required space is one of the few things CC9 cannot solve, so we are not looking into this.
Water, nutrients, and pest control are different. A farmer can either irrigate, apply fertilizer or spray against pests, or he can use crop varieties that require fewer growth factors and are resistant to pests, to name but a few.
An alternative for irrigation is making the plants tolerate heat and droughts. As one can imagine, shielding the fields is not a viable option, and Agri-photovoltaics (solar panels mounted above fields) is still mostly a research topic. You can guess what one solution might be.
Synthetic fertilizer can be substituted with an organic fertilizer like manure, but manure requires livestock, and livestock emit greenhouse gases. So, in the end, less fertilizer is the best option. This can be achieved by, guess what.
Pest control is a complex issue because many factors influence the distribution and severity, but it is important to secure the harvest. At the moment, pesticides are the way to go. One alternative is to use agronomic practices such as giving more space to each plant to decrease the spread of fungi or the breeding of resistant plants. For the former, the chances are limited, and in the worst case, one must still use pesticides. For the latter, we have already heard that CC9 can speed up this process.

The climate crisis is not waiting, the world population is growing fast, and solutions are needed quickly. In contrast to the use in humans and animals, which entails higher risks, the use of CC9 in plants is promising. It is shown that a plant's genome does change even without human interaction, so why should humanity not use this chance to increase the harvest and develop resistance against pests and consequently reduce hunger in the world?
Moreover, it must be noted that research is still ongoing and that the understanding of the positive and negative influence of CRISPR-Cas9 is increasing steadily. Surveillance mechanisms can be implemented to ensure ethical application and equal distribution of those crops, and in some countries, these already exist.
All in all, the benefits outweigh the risks. In brief, what is more important than feeding the growing world population?

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Summary:
The world population is growing, and at the same time the challenges to feed the people are increasing. One possibility to improve the yields of farmers is CRISPR-Cas9, a gene editing tool. But many people express concerns about the use of such means. In this essay, advantages and disadvantages of CRISPR-Cas9 are considered from an ethical point of view.