International Day of Halakhic Exploration: Questions and Answers the Jewish Way

"Halakhic Perspectives on Genetically Modified Organisms"

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November 2015 / CJLS YD 297

Questions:

- What halakhic values and norms should be applied to the genetic modification of organisms, whether plant or animal, particularly through the use of recombinant DNA?
- May Jewish consumers receive medical, nutritional and commercial benefit from genetically modified products?

Where Genetic Engineering Stands Now ...

Source #1: Basic Concepts

An organism that is generated through genetic engineering is considered to be genetically modified (GM) and the resulting entity is a genetically modified organism (GMO).

Genetic engineering is a process that alters the genetic make-up of an organism by either removing or introducing DNA. Unlike traditionally animal and plant breeding, which involves doing multiple crosses and then selecting for the organism with the desired phenotype, genetic engineering takes the gene directly from one organism and inserts it in the other. This is much faster, can be used to insert any genes from any organism (even ones from different domains) and prevents other undesirable genes from also being added.

Genetic engineering could potentially fix severe genetic disorders in humans by replacing the defective gene with a functioning one. It is an important tool in research that allows the function of specific genes to be studied. Drugs, vaccines and other products have been harvested from organisms engineered to produce them. Crops have been developed that aid food security by increasing yield, nutritional value and tolerance to environmental stresses.

The DNA can be introduced directly into the host organism or into a cell that is then fused or hybridized with the host. This relies on recombinant nucleic acid techniques to form new combinations of heritable genetic material….

Applications

<u>Medicine</u>

Genetic engineering has many applications to medicine that include the manufacturing of drugs, creation of model animals that mimic human conditions and gene therapy. One of the earliest uses of genetic engineering was to mass-produce human insulin in bacteria.

<u>Research</u>

Genetic engineering is an important tool for natural scientists. Genes and other genetic information from a wide range of organisms can be inserted into bacteria for storage and modification, creating genetically modified bacteria in the process. Organisms are genetically engineered to discover the functions of certain genes. These experiments generally involve loss of function, gain of function, tracking and expression.

Industrial

Organisms can have their cells transformed with a gene coding for a useful protein, such as an enzyme, so that they will overexpress the desired protein. Mass quantities of the protein can then be manufactured by growing the transformed organism in bioreactor equipment using industrial fermentation, and then purifying the protein…. These techniques are used to produce medicines such as insulin, human growth hormone, and vaccines, supplements such as tryptophan, aid in the production of food (chymosin in cheese making) and fuels. Other applications with genetically engineered bacteria could involve making them perform tasks outside their natural cycle, such as making biofuels, cleaning up oil spills, carbon and other toxic waste and detecting arsenic in drinking water.

Agriculture

One of the best-known and controversial applications of genetic engineering is the creation and use of genetically modified crops or genetically modified livestock to produce genetically modified food. Crops have been developed to increase production, increase tolerance to abiotic stresses, alter the composition of the food, or to produce novel products.

The first crops to be realized commercially on a large scale provided protection from insect pests or tolerance to herbicides. Fungal and virus resistant crops have also being developed or are in development. GM crops that directly improve yield by accelerating growth or making the plant more hardy (by improving salt, cold or drought tolerance) are also under development. In 2016 Salmon have been genetically modified with growth hormones to reach normal adult size much faster.

Other Applications

Genetic engineering has potential applications in conservation and natural area management. Gene transfer through viral vectors has been proposed as a means of controlling invasive species as well as vaccinating threatened fauna from disease. Transgenic trees have been suggested as a way to confer resistance to pathogens in wild populations. Novelty items such as lavender-colored carnations, blue roses, and glowing fish have also been produced through genetic engineering.

(Wikipedia, "Genetic Engineering")

Jewish Sources

The Biblical Level: The Principle of Preserving Distinction

Source #2: Leviticus 19:19 / ויקרא יט, יט

אֶת-חֻקֹּתַי תִּשְׁמֹרוּ בְּהֶמְתְּךָ לֹא-תַרְבִּיעַ כִּלְאַיִם שָׂדְךָ לֹא-תִזְרַע כִּלְאָיִם וּבֶגֶד כִּלְאַיִם שַׁעַטְנֵז לֹא יַעֲלֶה עָלֶיךָ:

You shall heed my statutes: you shall not let your cattle mate with a different kind; you shall not sow your field with two kinds of seed; and clothing made of two kinds of yarn you shall not put on yourself

Source #3: Deuteronomy 22:9–11 / דברים כב, ט-יא

לֹא-תִזְרַע כַּרְמְךָ כִּלְאָיִם פֶּן-תִּקְדַּשׁ הַמְלֵאָה הַזֶּרַע אֲשֶׁר תִּזְרָע וּתְבוּאַת הַכָּרֶם: (י) לֹא-תַחֲרֹשׁ בְּשׁוֹר-וּבַחֲמֹר יַחְדָּו: (יא) לֹא תִלְבַּשׁ שַׁעַטְנֵז צֶמֶר וּפִשְׁתִּים יַחְדָּו :

9. You shall not sow your vineyard with a second kind of seed [else the fullness from the seed you have sown, and the yield of the vineyard, may not be used]. 10. You shall not plow with an ox and ass together. 11. You shall not wear cloth combining wool and linen.

The Biblical Level: The Principle of Human Mastery

Source #4: Psalm 8: 5-10 / מזמור ח, ה-י

(ה) מָה־אֱנוֹשׁ כִּי־תִזְכְּרֶנּוּ וּבֶן־אָדָם כִּי תִפְקְדֶנּוּ: (ו) וַתְּחַסְּרֵהוּ מְּעַט מֵאֱלֹהִים וְכָבוֹד וְהָדָר תְּעַטְּרֵהוּ:
(ז) תַּמְשִׁילֵהוּ בְּמַעֲשֵׂי יָדֶיךָ כֹּל שַׁתָּה תַחַת־רַגְלָיו: (ח) צֹנָה וַאֲלָפִים כֻּלָּם וְגַם בַּהֲמוֹת שָׂדָי: (ט) צִפּוֹר
שָׁמַיִם וּדְגֵי הַיָּם עֹבֵר אָרְחוֹת יַמִּים: (י) יְקֹוָק אֲדֹנֵינוּ מָה־אַדִּיר שִׁמְךָ בְּכָל־הָאָרֶץ:

What are humans, that You have been mindful of them, mortals, that You have taken note of them, that You have made them little less than divine, and adorned them with glory and majesty; You have made them master over Your handiwork, laying the world at their feet, sheep and oxen, all of them, and wild beasts too; the birds of the heavens, the fish of the sea, whatever travels the paths of the seas. O Lord, our Lord, how majestic is Your name throughout the earth!

Source #5 : Genesis 30: 37-39 / בראשית ל, לז-לט

לז וַיִּקַּח־לוֹ יַעֲקֹב מַקֵּל לִבְנֶה לַח וְלוּז וְעֶרְמוֹן וַיְפַצֵּל בָּהֶן פְּצָלוֹת לְבָנוֹת מַחְשֹׂף הַלְּבָן אֲשֶׁר
עַל־הַמַּקְלוֹת:
לח וַיַּצֵּג אֶת־הַמַּקְלוֹת אֲשֶׁר פִּצֵּל בָּרֳהָטִים בְּשִׁקְתוֹת הַמָּיִם אֲשֶׁר תָּבֹאן הַצֹּאן לִשְׁתּוֹת לְנֹכַח
הַצֹּאן וַיֵּחַמְנָה בְּבֹאָן לִשְׁתּוֹת:
לט וַיֶּחֱמוּ הַצֹּאן אֶל־הַמַּקְלוֹת וַתֵּלַדְן הַצֹּאן עֲקֻדִּים נְקֻדִּים וּטְלָאִים:

Jacob took himself rods from moist poplar, almond, and plane trees and peeled white peelings in them, exposing the white that was on the rods, then he presented the rods that he had peeled in the gutters, in the water troughs where the flock would come to drink, in front of the flock. Now they would be in heat as they came to drink; thus the flock came to be in heat by the rods, and the flock bore streaked, specked, and dappled young.

Source #6 : Bereshit Rabbati, Vayetze (p. 129)

That you have made them little less than divine—This refers to Jacob, for it says (in Genesis 30:39), *and since the goats mated by the rods*…. Rabbi Hoshaya explains, "He would draw an image, and just as he drew, so the seed formed in the water of their wombs, and so did they give birth. This teaches that [Jacob] lacked only the ability to give them a soul."

Rabbinic Source: Establishing Guidelines for Kilayim

Source #7: Talmud Yerushalmi, Tractate Kilayim 1:1 (Venice ed., 27a)

How do we know that one may not graft a barren tree onto a fruit tree, nor a fruit tree onto a fruit tree of a different species? Because it [the Torah] states: Guard my statutes. R' Yonah [quotes] R' 'Lazar in the name of Kahana: It is in accord with R. 'Lazar's saying—"the statutes—are those that I have established in My world." Henceforth it is forbidden [to blend species] since Adam the First. R' Yosi in the name of Rabbi Hila [says], all agree that [the prohibition derives from the word] "statutes" that I have established in my world. Henceforth it is forbidden to graft a black fig [tree] onto a white fig [tree].

The Post-Rabbinic Debate

Source #8: Nachmanides (Ramban, 1194-1270), Torah Commentary on Leviticus 19:19 (Source #2 above): God created the species to persist.

The reason for Kilyaim [the ban in mixing species] is that God created the species in the world—all life forms among the plants and moving animals—and placed within them the

power of reproduction, so that the species would persist forever, [at least] so long as the Blessed One should desire that the world exist. And He made in them the capacity to replicate themselves and never change, as it says of them all, *according to their species* (Genesis 1). And this is the reason for sexual intercourse that animals mount one another to sustain their species, just as men and women have intercourse for the sake of reproduction. But when one grafts two different species, he alters and undermines the work of creation, and it is as if he thinks that the Holy One did not complete the work as needed, and now he wants to help in the creation of the world by adding new creatures to it. And [furthermore] the species are not fertile with members of other species, and even the closely related species in nature that are able to produce [hybrids] together, as with mules—their stock will cease, for they are sterile. And for these two reasons, the creation of hybrid species is despicable and futile….

And I have already written in the Order of Creation (Genesis 1:11) that the plants all have their source in the heavens, and from there God gave them their blessing to live forever. But a person who blends together species undermines, and mingles the work of creation

Source #9: Maimonides (Rambam, 1139–1205), Mishneh Torah, Law of Kilayim 1:4: Limits and Applications

The prohibition on mixed seeds is limited to species fit for human consumption, but bitter grasses and such from roots which are not fit except for [eating, but only for] medicine, and similar [plants] are not included in the ban on mixed seeds.

Source #10: Arukh HaShulḥan of Rabbi Yehiel Michel Epstein (1829–1908), Yoreh De'ah 84:36: What the naked eye cannot perceive (permissive)

In truth, the Torah did not forbid anything that the [naked] eye cannot perceive, for the Torah was not given to angels….

Source #11: Responsa of R' Shlomo Zalman Auerbach (1910–1995), Minḥat Shlomo II, 100:7: What the naked eye cannot perceive (prohibitive)

Regarding his question regarding genetic engineering, where they insert cellular materials from one organism to another, and in so doing transform the structure of the second, whether this action can be exempted from the prohibition of kilayim since these cellular materials are not visible to the [naked] eye: [In my opinion,] since the workers are manipulating these materials, and transferring them from one species to another, this should certainly be considered as "visible to the eyes," and it is not comparable to [the permission to eat] microscopic worms, which are not seen.

Back to Science: Did God build genetic engineering into the system?

Source #12: "Expression of multiple horizontally acquired genes is a hallmark of both vertebrate and invertebrate genomes," Alastair Crisp, Chiara Boschetti, Malcolm Perry, Alan Tunnacliffe, and Gos Micklem in *Genome Biology*, 201516:50 (excerpts).

A fundamental concept in biology is that heritable material, DNA, is passed from parent to offspring, a process called vertical gene transfer. An alternative mechanism of gene acquisition is through horizontal gene transfer (HGT), which involves movement of genetic material between different species.

Our analyses suggest that while fruit flies and nematodes* have continued to acquire foreign genes throughout their evolution, humans and other primates have gained relatively few since their common ancestor.

The distribution of transfer events is different in the primates, with most foreign groups mapping to the base of the tree (a common ancestor of primates), suggesting that the majority of HGT in primates is ancient. In these cases we are not inferring that the HGT event occurred in the most recent common ancestor of all primates, but that it occurred sometime between the common ancestor of Chordata** and the common ancestor of the primates….

….it appears that, far from being a rare occurrence, HGT has contributed to the evolution of many, perhaps all, animals and that the process is ongoing in most lineages. Between tens and hundreds of foreign genes are expressed in all the animals we surveyed, including humans. The majority of these genes are concerned with metabolism, suggesting that HGT contributes to biochemical diversification during animal evolution.

* a roundword or threadworm

**an animal of the large phylum Chordata, comprising the vertebrates together with the sea squirts and lancelets.