**International Day of Halakhic Study and Exploration:**

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**“Halakhic Perspectives on Genetically Modified Organisms”**

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The full text of this teshuvah is available for download from the Rabbinical Assembly website:

<https://www.rabbinicalassembly.org/sites/default/files/assets/public/halakhah/teshuvot/2011-2020/nevins-gmos.pdf>

Humans have been modifying the species around them through selective breeding since the origins of civilization in the Neolithic period. As recently as Darwin it was assumed that, “Man…can neither originate varieties, nor prevent their occurrence; he can preserve and accumulate such as do occur.”[[1]](#footnote-1) In recent decades, however, it has indeed become possible to originate varieties with increasing sophistication. The latest technology, called CRISPR/CAS9, allows scientists and even hobbyists to remove segments of DNA, insert replacements, and to ensure that the modification can be inherited by the next generation.

Gene editing has many potential benefits—in agriculture, nutrition, medicine and more. Vast sums of money are being invested in genetic engineering, yet many basic questions remain unanswered. How to ensure that each modification is safe for current and future generations? Who owns DNA? What is the species status of transgenic organisms? Should there be limits to the mingling of different species? Most people think that human life should be privileged over other species—but what about mice with human DNA? What about humans with DNA from other animals? When humans become creators of new species, what becomes of our belief in God as Creator? What guidance does Jewish law offer?

Our text study begins with the Torah’s prohibition of mingling species, and proceeds to a broad sampling of rabbinic texts from Talmud and Midrash, Jewish law, philosophy and mysticism. You will notice many nuances among these texts. Some indicate a sacred trust to preserve nature as is, while others support an activist agenda to perfect the world. What do you think? Listen to the voices of our ancient sages, and add yours to the sacred conversation!

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|  ? |  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?
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Primary Sources of the Response:

For those who wish to begin with a clarification of the science, technology and applications of genetic engineering and GMO products, see Source #12 below on page 5

**Jewish Sources**

**The Biblical Level: The Principle of Preserving Distinction**

**Source #1: 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 #2: 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 #3: 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) צֹנֶה 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 #4: Genesis 30: 37-39 / בראשית ל, לז-לט**

לז וַיִּֽקַּֽח־ל֣וֹ יַעֲקֹ֗ב מַקַּ֥ל לִבְנֶ֛ה לַ֖ח וְל֣וּז וְעֶרְמ֑וֹן וַיְפַצֵּ֤ל בָּהֵן֙ פְּצָל֣וֹת לְבָנ֔וֹת מַחְשֹׂף֙ הַלָּבָ֔ן אֲשֶׁ֖ר עַל־הַמַּקְלֽוֹת׃

לח וַיַּצֵּ֗ג אֶת־הַמַּקְלוֹת֙ אֲשֶׁ֣ר פִּצֵּ֔ל בָּרֳהָטִ֖ים בְּשִֽׁקֲת֣וֹת הַמָּ֑יִם אֲשֶׁר֩ תָּבֹ֨אןָ הַצֹּ֤אן לִשְׁתּוֹת֙ לְנֹ֣כַח הַצֹּ֔אן וַיֵּחַ֖מְנָה בְּבֹאָ֥ן לִשְׁתּֽוֹת׃

לט וַיֶּחֱמ֥וּ הַצֹּ֖אן אֶל־הַמַּקְל֑וֹת וַתֵּלַ֣דְןָ הַצֹּ֔אן עֲקֻדִּ֥ים נְקֻדִּ֖ים וּטְלֻאִֽים׃

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 #5: Bereshit Rabbati, Vayetze (p. 129)**

ותחסרהו מעט מאלהים (תהלים שם ו') זה יעקב שנאמר ויחמו הצאן אל המקלות. א"ר הושעיא היה צר צורה וכשם שהיה צר נעשו המים זרע בתוך מעיהם וכך היו יולדות, מלמד שלא היה חסר אלא לתת בהם נפשות.

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 #6: Talmud Yerushalmi, Tractate Kilayim 1:1 (Venice ed., 27a)**

מניין שאין מרכיבין עץ סרק על גבי עץ מאכל ולא עץ מאכל על גבי עץ מאכל מין בשאינו מינו מניין תלמוד לו' את חקותי תשמורו ר' יונה ר' לעז' בשם כהנא דר' לעזר היא משום חוקים שחקקתי בעולמי מעתה אסור לאדם הראשון ר' יוסי בשם רבי הילא דברי הכל היא משום חוקים שחקקתי בעולמי מעתה אסור להרכיב תאינה שחורה על גבי תאינה לבנה.

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 #7: Sefer HaHinukh (anonymous, 13th c., Barcelona), #545, Sending off the mother bird…: God created the species to persist.**

משרשי המצוה לתת אל לבנו שהשגחת האל ברוך הוא על בריותיו במין האדם בפרט, כמו שכתוב כי עיניו על כל דרכי איש וגו', ובשאר מיני בעלי חיים במינין דרך כלל, כלומר שחפצו ברוך הוא בקיום המין, ועל כן לא יכלה לעולם מין מכל מיני הנבראים, כי בהשגחת החי וקיים לעד ברוך הוא על הדבר ימצא בו הקיום, ובהניח האדם דעתו על זה יבין דרכי ה' ויראה כי המשכת קיום המינין בעולם שלא כלה ואבד אחד מכולם מביצי כנים ועד קרני ראם מיום שנבראו הכל במאמרו וחפצו על זה.

The purpose of this commandment is to make us aware that God’s providence is over all His creatures—especially over humanity, as it says, “*for His eyes are upon the ways of humanity*” (Job 34:21). And over other living species [God’s providence] is general. That is to say, that He, may He be blessed, wills the existence of the species, and therefore not one of the created species will ever go extinct, for it is within the providence of the blessed One who lives and lasts forever, over each thing that exists. And when a person contemplates this, he will know the ways of God, and see [God’s glory] in the continued existence of the species in the world, that not one of them goes extinct and is lost, from eggs in the nest to the mighty horned-ram, from the day that they were created—all that exists is according to [God’s] word and will.

**Source #8: Maimonides (Rambam, 1139-1205), Mishneh Torah, Law of Kilayim 1:4: Limits and Applications**

אין אסור משום כלאי זרעים אלא הזרעים הראויין למאכל אדם, אבל עשבים המרים וכיוצא בהן מן העיקרין שאינן ראויין אלא לרפואה וכיוצא בהן אין בהן משום כלאי זרעים.

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 #9: Arukh HaShulhan of Rabbi Yehiel Michel Epstein (1829–1908), Yoreh De’ah 84:36: What the naked eye cannot perceive (permissive)**

האמת הוא דלא אסרה תורה במה שאין העין שולטת בו דלא ניתנה תורה למלאכים.

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

**Source #10: Responsa of R’ Shlomo Zalman Auerbach (1910-1995), Minhat Shlomo II, 100:7: What the naked eye cannot perceive (prohibitive)**

בענין שאלתו בדבר הנדסה גנטית, שמכניסים חלקיקי תאים מבריה אחת לשניה, ובזה משנים את תכונותיה של השניה, ועי"ז להתיר איסור כלאים מכיון שאין חלקיקים אלו נראים לעין האדם, כיון שאנשים מטפלים בחלקיקים האלה ומעבירים אותם ממין אחד לשני הרי זה חשיב ממש כנראה לעינים ולא דמי כלל לתולעים שאינם נראים.

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.

**The Science: Did God build genetic engineering into the system?**

**Source #11: “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.

**Where Genetic Engineering Stands Now …**

**Source #12: Nevins, pgs. 4, 5, 6, 7, 8, (excerpted)**

Genetic engineering, which involves the direct modification of DNA, was first demonstrated in 1973 by Herbert Boyer, Paul Berg and Stanley Cohen (who coaxed bacteria to develop foreign proteins), and the field has grown rapidly since then from manipulating the DNA of yeast and bacteria to that of plants, fish, birds and mammals. By the 1980s researchers were capable of inserting DNA from one species into the fertilized egg of a different species, producing new specimens with hybrid characteristics, which are referred to as transgenic. Zebra fish have received the DNA of coral and sea anemones to make them glow; salmon have been artificially endowed with the DNA of deep sea eels (ocean pout) to make them grow year-round; and goats have had snippets of human DNA inserted into their fertilized ova to cause them to produce enzymes such as antithrombin and lysozyme for human benefit.[[2]](#endnote-1) The resulting recombinant DNA includes sequences from both of the original organisms, even though they are of different species that could not naturally reproduce together.

Methods for blending the DNA of different species have become ever more sophisticated, from the initial insertion of foreign DNA into a fertilized egg using a micro-syringe, to more recent efforts that employ a “gene gun,” agrobacteria, or modified viruses to transfer DNA from one organism to another. An international industry known as “pharming” has arisen to develop genetically modified organisms to grow medications and other substances such as biofuels that are useful to humans.

Genetic engineering is a field of great promise in combating hunger and disease.[[3]](#endnote-2) Genetically modified crops, first introduced in 1994 with the FlavrSavr Tomato (approved, but then removed from market), had by 2013 been planted on 420 million acres, including half the world’s soybeans and a third of its corn.[[4]](#endnote-3) Many scientists believe that it will be impossible to feed the world’s rapidly growing human population without genetically modified crops.[[5]](#endnote-4) Not only may such crops reduce the need for herbicides, but some seeds such as Golden Rice are engineered to include Vitamin A and thus to combat vitamin deficiencies that cause blindness in a half million children each year. J.R. Simplot’s USDA-approved modified potato has been designed to produce less acrylamide, a possible carcinogen, when fried.[[6]](#endnote-5) Some crops would be wiped out by fungus or infestations without their genetic modification. However, concerns about the safety of some of these products persist; for example, genetically modified corn may be grown using neonicotinoids, a class of neurotoxic insecticides that activists have claimed to have played a role in the recent collapse of honeybee populations, and may even disrupt nerve-cell activity in mammals.[[7]](#endnote-6) Scientific reviews have not, however, confirmed these claims.[[8]](#endnote-7) GM cotton crops often integrate the insecticide Bt in every cell, which may be causing the selection for resistance in “superbugs,” leading farmers to increase the use of pesticides. Attacks and defenses of GMOs on health grounds are contentious and complex, defying simple conclusions. Regulations to alert consumers to the use of genetically modified products (such as those already in place in Europe), and continued study of their ramifications for animal and human health are certainly warranted.[[9]](#endnote-8)

Aside from the development of new foods, genetic engineering has become increasingly significant in medical research and therapy. Long-term safety trials have already been completed for certain genetically modified medications, some of which are indispensable to the contemporary pharmacy. In 1978 the first synthetic human insulin was bioengineered using E. coli, and in 1982, Eli Lilly and Company marketed the first commercial product of bioengineered insulin under the brand name Humulin. In 2007 the company SemBioSys announced plans to bioengineer insulin by introducing the human gene for insulin production into safflower plants, thereby reducing the costs of creating this vital medication. The majority of insulin produced today is made from biosynthetic processes using bacteria and yeast to grow this important medical product.[[10]](#endnote-9)

Cancer researchers have capitalized on the human immune system’s intolerance for certain foreign DNA to stimulate auto-antibodies to inhibit the growth of cancer cells. Another anti-cancer gene therapy modifies DNA from a pig and introduces it to a tumor site within a human in order to induce an auto-immune response from the host to attack the tumor. Yet another promising field is immunoprophylaxis by gene transfer (IGT), a form of genetic engineering that seeks to re-engineer human DNA for permanent resistance to a broad spectrum of viruses.

Endnotes from Nevins, pgs. 4, 5, 6, 7, 8 (excerpted)

1. Charles Darwin, *The Origin of Species* (NY: Signet Classics, 2003), p. 76. [↑](#footnote-ref-1)
2. Antithrombin is an anticoagulant made by the human liver that prevents blood clots from forming; lysozyme is an enzyme found abundantly in human breast milk that destroys harmful bacteria such as E. coli, protecting the child from dysentery, and allowing the development of a stronger immune system. Both products might be “pharmed” to produce medication for humans who have a deficiency of the requisite enzyme. These experiments are discussed by Anthes in *Frankenstein’s Cat.* [↑](#endnote-ref-1)
3. Genetically modified rice has, it is claimed, the potential to alleviate global hunger, malnutrition and poverty. See Dermont, M. and Stein, A.J., “Global Value of GM Rice: A Review of Expected Agronomic and Consumer Benefits” in *New Biotechnology* (2013). Still, there are unresolved controversies about the safety and also the ethics of GM crops, since the GM products of agribusiness giants such as Monsanto are displacing the unmodified crops of subsistence farmers, requiring them to purchase new seed annually rather than simply reserving some of their traditionally grown crops for replanting. Organic farmers have likewise taken [legal action](http://www.huffingtonpost.com/2013/06/10/monsanto-wins-lawsuit_n_3417081.html) out of concern that their crops would become contaminated by GM pollen, leading patent owners to sue farmers for unintentional copyright violation. [↑](#endnote-ref-2)
4. See the following USDA web site for data on the adoption of genetically engineered crops by American farmers: <http://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us.aspx> [↑](#endnote-ref-3)
5. I realize of course that many causes of hunger are of a political, economic and even cultural nature. If crops cultivated to feed animals for meat production were replaced with vegetables intended for human consumption, the farms of America alone could feed the world on a vegetarian diet. Still we cannot assume that human appetites for meat, and also for financial profit, will be eliminated. Perhaps the development of cultured (lab-grown) meat will address human appetites in a way that is more efficient, ethical and less polluting in the future. This is the subject of my next halakhic study. [↑](#endnote-ref-4)
6. Andrew Pollack, “[U.S.D.A. Approves Modified Potato](http://www.nytimes.com/2014/11/08/business/genetically-modified-potato-from-simplot-approved-by-usda.html?module=Search&mabReward=relbias%3As%2C%7B%221%22%3A%22RI%3A5%22%7D),” *New York Times*, Nov. 7, 2014. [↑](#endnote-ref-5)
7. ##  An article defending GMOs is found in Michael Specter, “Seeds of Doubt: An Activist’s Controversial Crusade against Genetically Modified Crops,” in *The New Yorker* (August 28, 2014). For a critical response, see “Rooted in Science,” letter to the editor by Eric Chivian published in response to “Seeds of Doubt,” *The New Yorker* (September 15, 2014), and Ramon J. Seidler’s essay, “[Pesticide Use on Genetically Engineered Plants](http://static.ewg.org/agmag/pdfs/pesticide_use_on_genetically_engineered_crops.pdf),” in EWG *AgMag* (September 2014).

 [↑](#endnote-ref-6)
8. See “[Risks of Neonicotinoid Insecticides to Honeybees](http://onlinelibrary.wiley.com/store/10.1002/etc.2527/asset/etc2527.pdf?v=1&t=i1gtsd6p&s=db1c881462a966ac2f9d22e85ad18064ee18e7c9),” by Anne Fairbrother, John Purdy,Troy Anderson and Richard Fell in *Environmental Toxicology and Chemistry, (*[Volume 33, Issue 4),](http://onlinelibrary.wiley.com/doi/10.1002/etc.v33.4/issuetoc)pages 719–731, April 2014. They conclude, “However, under field conditions and exposure levels, similar effects on honeybee colonies have not been documented. It is not reasonable, therefore, to conclude that crop-applied pesticides in general, or neonicotinoids in particular, are a major risk factor for honeybee colonies, given the current approved uses and beekeeping practices.” [↑](#endnote-ref-7)
9. A [FAQ document](http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/) by the World Health Organization includes links to detailed documents such as [Principles for the risk analysis of foods derived from modern biotechnology](http://www.codexalimentarius.org/download/standards/10007/CXG_044e.pdf). [↑](#endnote-ref-8)
10. See this [page](http://www.iptv.org/exploremore/ge/what/insulin.cfm) from Iowa Public Television for a graphic illustration of the process, and this YouTube instructional [video](https://www.youtube.com/watch?v=H7FdzpE2GIE). [↑](#endnote-ref-9)