Pareve Cloned Beef Burgers: Health and Halakhic Considerations

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New stem cell and gene editing biotechnologies are causing a paradigm shift in the food industries. While biotechnologies have consistently improved upon the production of many types of foods,[1] including cheese,[2] wine,[3] fruit,[4] and crops,[5] these new technologies are changing the fundamental way in which we think about what we eat, the sources of our food,

1 Tyagi A, Kumar A, Aparna SV, Mallappa RH, Grover S, Batish VK, "Synthetic biology: applications in the food sector," *Critical Reviews in Food Science and Nutrition*. 2016 Aug 17;56 (11): 1777–89.

2 Delorme C, Legravet N, Jamet E, Hoarau C, Alexandre B, El-Sharoud WM, Darwish MS, Renault P, "Study of Streptococcus thermophilus population on a world-wide and historical collection by a new MLST scheme," *International Journal of Food Microbiology,* 2017 Feb 2; 242:70–81.

3 Arevalo-Villena M., Briones-Perez A., Corbo M.R,2, Sinigaglia M., Bevilacqua "A. Biotechnological application of yeasts in food science. starter cultures, probiotics, and enzyme production," *J Appl Microbiol*, 2017 Jul 26. doi: 10.1111/jam.13548. [Epub ahead of print].

4 Gascuel Q, Diretto G, Monforte AJ, Fortes AM, Granell "A. Use of Natural Diversity and Biotechnology to Increase the Quality and Nutritional Content of Tomato and Grape," *Frontiers in Plant Science*. 2017;8.

5 Ahmad N., Mukhtar Z., "Genetic modifications of crop plants: Issues and challenges," *Genomics*, 2017 Aug 1. P ii: S0888-7543(17)30063-0. doi: 10.1016/j.ygeno.2017.07.007. [Epub ahead of print].

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and how we feel about the new "lab-to-table" (rather than "farm-to-table") food production. In this article, we will discuss the potential health and halakhic ramifications of these technologies with respect to making meat and poultry products from non-traditional food sources.

The possibility of growing meat in an industrial setting has long captured the public imagination. Winston Churchill suggested in 1931, "We shall escape the absurdity of growing a whole chicken in order to eat the breast or wing, by growing these parts separately under a suitable medium."[6] In 2002, scientists from NASA reported the need to develop viable means of supplying safe, healthy, nutritious food to space voyagers on long journeys.[7] They investigated the potential of providing cultured adult dorsal abdominal skeletal muscle mass from goldfish as a cell source and generating crude explants which resembled fresh fish filets. They hoped the method of growing fish filets in a laboratory could serve as a renewable food source for human space travel. Unfortunately, cultured goldfish fillets never caught on.[8]

Since NASA's first attempt to create a cultured fish product, several startup companies have made advances in the field. Memphis Meats, a Silicon Valley startup founded by a cardiologist, launched a video in February 2016 showcasing its cultured beef meatball.[9] In March 2017, the company showcased chicken tenders and duck a-l'orange, the first cultured poultry-based foods shown to the public. Another startup, Mosa Meats, produced the first commercial cloned hamburger for culinary experts to taste.[10] In 2013, Dr. Mark Post from Mosa Meats made headline news around the world for producing the world's first lab-grown burger that was cooked and eaten at a news conference in London. The burger was made from real meat grown in a lab (20,000 strips of muscle tissue) at a cost of $325,000. This first cloned burger was cooked by chef Richard McGeown of Couch's Great House Restaurant in Cornwall and tasted by Hanni Ruetzler, a food critic and food researcher at the Future Food Studio in London. Ruetzler described the experience. "There is really a bite to it, there is quite some flavor with the browning. I know there is no fat

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6 http://teachingamericanhistory.org/library/document/fifty-years-hence/.

7 Benjaminson, M.A., Gilchriest, J.A., Lorenz, M., "In vitro edible muscle protein production system (MPPS): Stage 1, fish," *Acta Astronaut*, Volume: 51, Issue: 12, 2002, pp. 879–889.

8 http://gizmodo.com/the-future-will-be-full-of-lab-grown-meat-1720874704.

9 http://www.memphismeats.com/.

10 http://fortune.com/2017/03/15/memphis-meats-lab-grown-chicken-peta/; https://www.wsj.com/articles/sizzling-steaks-may-soon-be-lab-grown-1454302862.

in it so I didn't really know how juicy it would be, but there is quite some intense taste; it's close to meat, it's not that juicy, but the consistency is perfect. This is meat to me… It's really something to bite on and I think the look is quite similar."[11] According to a recent ABC News interview with Post, the cost of a cloned burger has dropped to just over $11 for a burger ($80 per kilogram of meat).[12] An Israeli company, SuperMeat, ran a viral crowdfunding campaign in 2016 for its work on using stem cells to produce cultured chicken meat.[13]

Lab-to-Table Process

New stem cell biotechnologies are being employed to create "clean meat" or cloned meat.[14] The technical methods have yet to be published in peer-review articles, but here is a general description of the type of process that various companies that are developing these technologies would use to turn muscle precursor cells into meat fit for consumption. Briefly, this process begins by carefully removing muscle tissue from a living cow's neck muscle via a small syringe without harming the animal. Muscle precursor cells, such as myosatellite cells, are then separated from the other cells in the tissue sample[15] and grown in vitro in a bio-reactor.

When muscle precursor cells are separated to be grown in a bioreactor, they are placed in a medium, where they have all the necessary nutrients to multiply. These stem cells rapidly divide and eventually differentiate to generate muscle fibers that form the essential component of animal-derived meat. The cell multiplication creates thin layers of cells or loose cells. To turn these cells into muscle tissue, they must be injected into a scaffolding gel through which they can organize and connect to form muscle tissue. The difficulty with this process is that the forming muscle tissue does not contain a way to transport nutrients and oxygen to the cells and waste away from the cells (such as veins carrying blood in real animals). Therefore, only tissue that is near the surface has this ability

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11 http://www.bbc.com/news/science-environment-23529841.

12 https://www.fastcompany.com/3044572/the-325000-lab-grown-hamburger-now-costs-less-than-12.

13 http://www.supermeat.com/.

14 Post MJ. "Cultured beef: medical technology to produce food," *Journal of the Science of Food and Agriculture*. 2014 Apr 1; 94(6):1039–41; Moritz MS, Verbruggen SE, Post MJ. "Alternatives for large-scale production of cultured beef: a review," *Journal of Integrative Agriculture*. 2015 Feb 1;14(2):208–16.

15 There are a variety of ways, such as fluorescence-activated cell sorting or magnetic beads, to separate the individual stem cells from the other components of the retrieved muscle sample.

while cells in the tissue's interior tend to die from lack of nutrition. An alternative method is to create muscle tissue through 3-D printing. Even after the tissue is composed, the tissue must be "exercised" (muscle contraction) to become mature enough to become edible muscle tissue. Tissue can be "exercised" either through electronic or chemical stimulation.

There are scientific challenges to culturing myosatellite cells from cows. First, this stem cell type is a rare muscle cell with limited regenerative potential. Second, these cells are prone to malignant transformation in long-term culture, and we do not know the health risks of consuming such malignant cells.[16] From a public relations perspective, even if companies mitigate the risk of malignant transformation of cells in long-term culture, they would have to avoid the public fear of consuming "bovine cancer cells." To minimize this risk, many companies are already choosing to start new cultures from muscle tissue harvested from animals every few months. Third, currently maintaining these cells in culture requires that they be bathed in fetal cow sera, a costly media component that also may not be ethically acceptable to potential consumers because, in part, animal sera require the sacrifice of many fetal calves, questioning whether this process will really reduce animal use and suffering. Research is rapidly trying to develop animal-serum-free media to overcome the use of animal sera. The final challenge is whether cultured meat will have the same taste, texture and barbecue potential as animal-derived meat. Ninety-six percent of Americans eat fast food meats and love their taste and believe plant-made meat does not adequately mimic the taste, convenience, and barbecuing potential of animal-based meats.

Health Benefits

There are many potential health advantages to cultured meat.[17,18,19] First, producing cloned or synthetic meat allows scientists to manipulate the flavor, fatty acid composition, fat content and ratio of saturated to poly-

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16 https://www.inverse.com/article/14260-does-eating-cancer-tumors-give-you-cancer-probably-not-but-put-the-burger-down.

17 Tuomisto, H. and Teixeira de Mattos, J. (2011) "Environmental impacts of cultured meat production," *Environmental Science and Technology*, 45(14), pp. 6117–6123.

18 Hopkins, P. and Dacey, A. (2008) "Vegetarian meat: Could technology save animals and satisfy meat eaters?" *Journal of Agricultural and Environmental Ethics*, 21(6), pp. 579–596.

19 Hopkins, P. and Dacey, A. (2008) "Vegetarian meat: Could technology save animals and satisfy meat eaters?" *Journal of Agricultural and Environmental Ethics*, 21(6), pp. 579–596.

unsaturated fatty acids by genetic alterations, through adjusting the composition of the culture medium, and in co-culturing the cloned muscle cells with other cell types, such as fat cells. For example, health aspects of the meat can be enhanced by adding factors like certain types of vitamins or omega 3 substances to the culture medium.[20] Second, domestic animals used to produce meat occupy about 30 percent of the planet's ice-free land space and are currently wreaking incredible environmental damage. Cows release enormous amounts of methane, urine and waste that can contaminate and pollute the environment, rivers and streams.[21] Moving the production of meat from the farm to the lab could transform it to becoming a significantly greener industry. Third, there may be animal-welfare benefits because fewer animals will be needed to produce meat.[22] Finally, cloned poultry might have the advantage of lowering the risk of viral (avian flu) epidemics that spread via chickens.[23]

Currently, there are very few studies that rigorously evaluate and compare the health of omnivorous, vegetarian, and vegan subjects as distinct experimental groups. Some studies have shown that people on vegan diets have lower blood pressure, lower fasting triacylglycerol and glucose concentrations than omnivorous subjects, as well as a biochemical profile that is cardio-protective and diabetes protective. Other research groups suggest that vegetarian diets, especially vegan diets, are associated with lower bone mineral density (BMD), but this does not appear to be clinically significant. The problem with these studies is that they compared vegans only to omnivores, and not to individuals who are vegetarian. Strict vegetarian diets in general have been credited with improving insulin resistance, lowering diabetes risk, and lowering cardiometabolic disease risk.

While there are reports of the health risks associated with meat,[24] other reports[25] suggest that diets that allow moderate amounts of animal products may be protective against disease as well. A pooled analysis of

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20 Bhat, Z. and Bhat, H. (2011) "Animal-free meat biofabrication," *American Journal of Food Technology*, 6(6), pp. 441–459. doi: 10.3923/ajft.2011.441.459

21 Tuomisto, H. and Teixeira de Mattos, J. (2011) "Environmental impacts of cultured meat production," *Environmental Science and Technology*, 45(14), pp. 6117–6123.

22 Hopkins, P. and Dacey, A. (2008) "Vegetarian meat: Could technology save animals and satisfy meat eaters?" *Journal of Agricultural and Environmental Ethics*, 21(6), pp. 579–596.

23 https://www.theguardian.com/vital-signs/2015/jul/14/bird-flu-devastation-highlights-unsustainability-of-commercial-chicken-farming.

24 Wolk A. "Potential health hazards of eating red meat," *J Intern Med*, 2017 Feb;281 (2):106–122.

25 Derbyshire E.J., Front "Flexitarian Diets and Health: A Review of the Evidence-Based Literature." *Nutr*. 2017.

five prospective cohort studies, involving 76,000 subjects found that both vegetarians and those who followed a "prudent" diet allowing small amounts of red meat benefited from a reduced risk of coronary heart disease and type 2 diabetes.[23]

A critical focus in the development of "cloned meat" is in identifying the health benefits for such meat products when there are so many plant-derived meat substitutes that have been on the market for years. Despite the health comparison between "clean meat" and other meat alternatives, however, health benefits would accrue due to the social desire to consume cloned meat over vegetable-based meat alternatives. For example, 96% of Americans eat fast food meats, love their taste, and believe that plant-made meat does not adequately mimic it. Moreover, those who prefer low-quality meat over plant-based alternatives do so due to its convenience and its ability to be barbecued or cooked without losing its quality, taste, and texture, which is not the case with many plant-based alternatives. In other words, the public enjoys the taste of meat and plant-derived meats may not satisfy their taste buds.[26]

Halakhic Considerations in Producing Cultured Meat

To properly structure our halakhic analysis, we want to state at the beginning what it would take to consider cultured meat to be kosher. Once one recognizes what would make the meat kosher, it would then be easier to understand other halakhic considerations.

To satisfy all halakhic challenges, cloned beef would be universally accepted as kosher if:

1. The sample was obtained from a kosher animal.
2. The animal was properly slaughtered.
3. Cloned beef could be considered *pareve* (halakhically considered neither meat nor dairy) if the tissue from which the muscle stem cells are obtained comes from the skin. Skin has many stem cell–like cells that can transform in the laboratory into a wide variety of cell types, including nerves, liver, blood cells, lung cells etc. These cells can also be genetically re-programed into myosatelitte cells or muscle stem cells that will grow into muscle fiber in the laboratory.

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[26] An untested marketing advantage to this technology would be in its use to generate exotic cultured meats or even meat from rare, endangered or extinct animals that could be sold at premium prices.

The Sample Must Be Obtained from a Kosher Animal

There is a halakhic concept that "that which comes from a non-kosher animal is not kosher."[27] This applies to products that are derived from the non-kosher animal but not to products that are independent of the animal but found within it. For example, Maimonides writes, "Any food that is produced from forbidden species for which lashes are given for partaking of it is forbidden to be eaten according to Scriptural Law."[28] He also writes that, when a non-kosher animal gives birth to an offspring resembling a kosher animal, it is forbidden to be eaten…[The rationale is that offspring] produced by a non-kosher animal are not kosher… [However,] a non-kosher fish found in the belly of a kosher fish is forbidden, and a kosher fish found in the belly of a non-kosher fish is permitted, for they did not produce the fish, but instead, swallowed it."[29] The law that something that is extracted from an unkosher animal is forbidden is also recorded by Rabbi Yosef Karo in his code of Jewish Law, *Shulḥan Arukh*.[30]

The Animal Must Be Properly Slaughtered

Today, the way companies procure tissue to create cloned meat is through removing muscle tissue from a living cow's neck muscle via a small syringe without harming the animal. This process, however, would render the sample prohibited both for Jews, according to Halakhah, and for non-Jews, according to the Noahide laws.

For Jews, flesh removed from a live animal is considered flesh from a *treifah*, rendering it not kosher. This prohibition is derived from the verse "you shall not eat any flesh that is torn of beasts in the field."[31] In the Talmud, Rabbah explains how flesh from a live animal is categorized as flesh from a *treifah*, even if the animal itself would not be considered a *treifah*. He states, "Just as a *treifah* animal, once it has been rendered *treifah*, can never be permitted, so also flesh which had been removed from the animal while the animal is alive can never be permitted again."[32] The meaning of Rabbah's statement is as follows: The verse compares "flesh in a field" to *treifah*. Because *triefah* already includes flesh torn from a beast that is in a field, the explicit, repetitive mention of "flesh in a field" must

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27 *BT Bekhorot* 5b.

28 *Ma'akhalot Asurot* 3:1.

29 *Ma'akhalot Asurot* 1:5.

30 *Shulḥan Arukh, Yoreh De'ah* 81:3.

31 Exodus 22:30, ובשר בשדה טרפה לא תאכלו.

32 *BT Ḥullin* 68b.

include something other than what it normally considered *treifah*. "Flesh in a field" is thus understood as flesh that is no longer part of the animal but rather has been removed from it while it is still alive.[33] For non-Jews, this flesh would also be prohibited as flesh from a live animal.[34] The prohibition of eating flesh taken from a live animal is codified by Maimonides,[35] as well as Rabbi Yosef Karo in his *Shulḥan Arukh*.[36] Once the animal is ritually slaughtered,[37] the sample would be permissible to grow in culture to produce meat.

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33 *Tosafot, BT Ḥullin* 68b, s.v. "*ha-kol hayu bikhlal u-vasar ba-sadeh*."

34 For non-Jews, the prohibition of flesh from a live animal is subsumed within the prohibition of eating a limb from a live animal. Rabbi Yehonatan Eibeschutz, *Kreisi u-Pleisi, Yoreh De'ah* 62:3.

35 *Hilkhot Ma'akhalot Asurot* 4:10; *Hilkhot Melakhim* 9:10-11.

36 *Yoreh De'ah* 62:2.

37 Removing flesh from a kosher animal that has been ritually slaughtered but is still in its death throes would be prohibited to eat both for non-Jews and for Jews, albeit for different reasons. For non-Jews, the flesh would be considered flesh from a live animal, though for Jews it would not be. The reason for this distinction is based on the statement in the Talmud of Rabbi Aḥa bar Yaakov, that for meat to be kosher for Jews, the animal must be ritually slaughtered. Once ritually slaughtered, the animal is legally categorized as dead and thus, even in the animal's death throes, its flesh would not be considered as coming from a live animal. For non-Jews, however, the animal is legally categorized as dead only once it has in fact died. Therefore, eating flesh from the animal beforehand would be considered eating flesh from a live animal. This distinction was the basis for the midrash, quoted by Rashi, on the verse "Yosef brought evil tales about them to their father." (Gen. 37:2) Yosef believed that his brothers ate meat from a live animal, even though they ritually slaughtered it, because he believed that they were obligated by the Noahide law, while the brothers believed that, as the fathers of the tribes of Israel, they would be permitted to eat the animal once it was slaughtered.

Even though Jewish law does not usually permit something for Jews while prohibiting it for non-Jews, exceptions are made to this general principle when there is a rationale behind it. (See Rav Pappa's statement on *BT Ḥullin* 33a, "As I was Sitting before Rav Aḥa bar Yaakov, I thought of putting the question to him: Is there anything which is permitted to an Israelite and forbidden to a gentile? But I did not ask him this, for I said to myself: 'He has himself suggested the reason for it.'") This ruling is codified by Maimonides, who writes, "There are instances where a non-Jew would be held liable and a Jew will not, for a non-Jew is liable for a limb or flesh from a living creature whether from a domesticated animal or a beast, whether from a kosher or non-kosher species. Similarly, a non-Jew is forbidden to partake of a limb from a living creature for a limb or flesh which is separated from an animal that is moving convulsively even though a Jew has already severed the two signs [and thus the meat from this animal would be

Removing Blood

The Torah prohibits consumption of blood.[38] This is the only dietary law that has a reason specified in the Torah—that the life of the animal (literally, the soul of the animal) is contained in the blood. This applies only to the blood of birds and mammals, not to fish blood. Thus, in a regular situation of making meat kosher for consumption, it is necessary to remove all blood from the flesh of kosher animals.[39] To remove blood, meat must either be broiled or put through a soaking and salting process.[40]

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considered kosher]." (*Hilkhot Melakhim* 9:13.) However, even though the flesh would not be considered from a live animal for Jews, it would still be prohibited. The prohibition is based on the verse "Do not eat [the flesh of an animal] upon the blood." (Lev. 19:26. *Hilkhot Sheḥitah* 1:2.)

In practical application, this prohibition would not in truth apply, since by the time the sample was grown in culture and ready to be consumed, the animal that was ritually slaughtered would have already died. One may argue, however, that, at least for non-Jews, the flesh should still be prohibited as being taken from a live animal, since it is not the state of the animal when the flesh is eaten that is relevant but rather the state of the animal when the flesh is taken. In other words, the flesh is taken from a live animal and is thus prohibited, the fact that the animal dies subsequently does not change the status of the flesh ex post facto. However, the Talmud does in fact contradict this reasoning, claiming that the state of the animal when the flesh is eaten is the relevant factor. For example, Rav Idi bar Abin said in the name of Rav Yitzhak bar Ashian, "If a person wishes to be in good health he should cut off an olive's bulk of flesh from around the throat, salt it well, rinse it well, wait until the animal expires, and then eat it. Both Jew and non-Jew may eat it in this way." (*BT Ḥullin* 33a.) This suggestion is codified by Maimonides, "It is permitted to cut meat from it after it has been ritually slaughtered, but before it dies. That meat should be salted thoroughly, washed thoroughly, and left until the animal dies. Afterwards, it may be eaten." (*Hilkhot Sheḥitah* 1:2.)

38 Lev. 7:26-27; Lev. 17:10-14.

39 Nahmanides states: Because God created all the lower beings for the needs of man… and after the Flood… He permitted humankind to slaughter animals…because their life is for man…but the life within them should provide atonement for man and be sacrificed before the Blessed One and not be eaten since no living creature can eat life itself because all the lives belong to God as do the lives of men (Commentary on Leviticus 17:11). Nahmanides sees the prohibition against eating blood as a prohibition against eating life, a remnant of that ancient prohibition from before the flood that forbade man the eating of meat completely, because in the eyes of the Almighty the eating of any life was forbidden. After the eating of meat was permitted, only the prohibition against eating blood remained.

40 The *Shulḥan Arukh* rules that eating circulatory blood is a prohibition whereby the transgressor receives excision (*karet*). Blood that is found within the muscle

Rabbi Moshe Feinstein writes that to remove blood from meat so as to make the meat kosher to eat, one can use only the methods affirmed by Halakhah. Other processes that scientists have devised to remove blood from meat are not halakhically valid.[41] This halakhic process must be completed within 72 hours after the animal is ritually slaughtered and before the meat is frozen, chopped, or ground.[42]

The problem with removing a muscle-tissue sample from a ritually slaughtered cow is that salting or broiling the sample would destroy the muscle stem cells. However, one may nevertheless permit the cultured meat, despite the sample not being salted. A piece of meat that is rendered inedible through the preparation process yet afterwards becomes even more gustatory than it was previously does not lose its status as food and remains prohibited. Yet, this applies only to the meat itself. The blood that was absorbed within the meat would lose its prohibitory taste when the meat became inedible.[43] Given the process of cell growth for the muscle precursor cells to become cloned meat, the muscle precursor cells and the tissue that grows from it would be considered inedible throughout the process until the mature muscle tissue is processed into edible meat. Therefore, because the muscle-tissue sample would be prohibited only because of the blood taken with it and not on its own accord, when the muscle tissue regains its gustatory status in becoming cloned meat, it would no longer be prohibited because of the blood within it. Therefore, one is permitted to eat the cloned meat even if it is not salted before cooking. This would make cloned meat a healthier option for those who must watch their sodium intake.

Must the Media be Kosher?

One concern that has arisen is that the cultured meat may not be kosher, even if the muscle precursor cells are kosher, if the medium in which the cells grow is not kosher. The concern stems from making an analogy between the muscle precursor cells in the medium which produces cultured meat and unkosher rennet in milk which produces cheese. However, this

tissue that has moved within the piece of meat is prohibited by a negative prescription. If the blood stays within the meat tissue as part of the tissue, it would not be prohibited to eat. (*Shulḥan Arukh* 67:1) However, this permissibility would apply only to raw meat. Once meat is cooked, the blood within it would inevitably move, rendering the piece prohibited if it was not properly salted or broiled (*Shulḥan Arukh* 67:2).

41 *Iggerot Moshe, Yoreh De'ah* 2:23.

42 *Shulḥan Arukh* 69:12.

43 *Iggerot Moshe, Yoreh De'ah* 2:23.

analogy is not accurate since the two processes are not the same. Rennet is considered a catalyst (*davar hama'amid*) for the milk, turning the milk into cheese. Therefore, even though the milk is the main focus of the reaction, the rennet has significance, since it makes the cheese. Therefore, the rennet is not nullified by the milk mixture. In the process of growing cultured milk, on the other hand, the muscle precursor cells do not turn the medium into cultured meat. The muscle precursor cells consume the nutrients of the medium and grow into muscle tissue. Therefore, the medium has no substance as part of the cultured meat, and should not be considered as mixed with the cells to prohibit the cultured meat. Any part of the serum that is not consumed by the cells does not remain as mixed with the muscle tissue but rather is washed away. Thus, the use of non-kosher bovine serum to grow the stems cell should not be a halakhic problem.[44]

Though the process is not the same, one can draw an analogy between muscle precursor cells consuming the nutrients of the medium and the situation where unkosher substances are dissolved into honey. The analogy works based on an a fortiori argument. If the unkosher substances that are dissolved into the honey would not render the honey prohibited, then the medium that is consumed by the muscle precursor cells would not render the cultured meat prohibited either. In the situation where prohibited meat has fallen into honey and has dissolved into it, Rabbi Ovadia Yosef has ruled that whenever a prohibited ingredient has completely changed its state and has become part of the substance in which it fell, the ingredient loses its prohibited status.[45] Similarly, because the medium has been consumed by the cells, it no longer retains its former state to prohibit the consequent muscle tissue.

Because the muscle precursor cells consume the nutrients of the medium and grow into muscle tissue, one could find precedent in the Talmudic debate over a field that has been manured with the manure derived from an idolatrous source or a cow that has been fattened on beans derived from an idolatrous source, where one Tanna decides that the field may be sown and the cow slaughtered, while another decides that the field

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44 Even though cells and microorganisms consume the nutrients in a medium, in certain cases, such as considering the halakhic status of yeast and bacteria grown in a medium, some *poskim* and the Israeli rabbinate make an analogy to the fermentation process and not to a consumption process. This would make the status of the medium in which a culture grows significant in determining the halakhic status of the culture. See Blech, Zushe Yosef. 2008. *Kosher Food Production*. 2nd ed. Ames, Iowa: Wiley-Blackwell Pub. 103.

45 *Yabi'a Omer, Ḥelek* 8, *Yoreh De'ah, Siman* 11.

must lie fallow and the cow grow lean.[46] If permitted factors and prohibited factors both contribute to the growth of something, Rabbi Yosef Karo rules that one may rely on the contribution of the permitted factors to rule leniently and permit the product.[47]

This matter of the medium, however, may not be an issue in the future, since many laboratories across the globe are developing media that do not contain bovine serum. The main motivation is that bovine serum is extremely expensive. Yet, many people also do not support killing animals unnecessarily (and ironically) to produce cultured food.

Can Cultured Meat be *Pareve*?

Skin has many differentiated cells that can be transformed in the laboratory into a wide variety of cell types, including nerves, liver, blood cells, lung cells etc. These cells can also be genetically re-programed into myosatelitte cells or muscle stem cells that will grow into muscle fiber in the laboratory. At this point it is critical to understand this process of genetic engineering. The first step here is to isolate a skin cell (fibroblast) from the hide itself. This cell obtained from the hide can never generate muscle cells alone in the animal or laboratory. Scientists must transform these cells into muscle precursor cells in a two-step process. First, scientists must add to these cells substances called "transcription factors" that reprogram the genetics of the skin cell to become a stem cell similar to those cells found in the early embryo. These primordial cells can then further be reprogramed by adding specific hormones and biological substances to specifically direct their new transformation into muscle precursor cells, which then could serve as the source of the cloned meat. This human intervention creates a new cell, with a different expression of the cell's genetic code and, hence, a different actualized cellular structure. Therefore, although the cell now acts like a muscle cell, the only factor that must be considered to determine whether the resulting cloned meat is *pareve* is from where the cells originates.

Rabbi Moshe Feinstein writes that animal hides are not considered to be meat (so as not to prohibit their mixture with milk) by Torah law; they are, however, prohibited to be used with milk by rabbinic law. If, however, the hides are dried and all meat is removed from them, then, if the hides are made into gelatin, the gelatin is not included in this rabbinic prohibition. Therefore, gelatin produced from kosher slaughtered animal hides

46 *BT Avodah Zarah* 49a.

47 *Shulḥan Arukh, Yoreh De'ah* 142:11.

may be intentionally used with milk, provided that the hides are cleaned in order to remove any meat residue. This would also apply to dried animal bones that had all the meat removed.[48] Thus, if the tissue from which the muscle stem cells are obtained is derived from the dried hide of a kosher animal that has no meat attached to it, the resulting muscle tissue could be considered *pareve*.

One may argue, however, that there is a big difference between gelatin and cloned meat. Skin, sinews, and bones do not resemble the looks, texture, or taste of meat, whereas cultured meat does. Yet, this may simply be an issue of *mar'is 'ayin*, which is a rabbinic enactment that prohibits something in order to prevent a third party from viewing a person's actions and arriving at an incorrect conclusion that a forbidden action is permitted. Many kashrut organizations, and Halakhah in general, have already found many solutions to preventing *mar'is 'ayin* when it comes to *pareve* "meat" or "dairy" substitutes. Therefore, from the perspective of *mar'is 'ayin*, this should not be a reason to declare that cultured meat derived from dried hide or bone samples be considered as *fleishig* and not *pareve*.

From a practical perspective, if one can remove live stem cells from processed hides, then the cloned, genetically engineered meat would be considered *pareve*. If one cannot remove live cells from the processed hides, since the cells would die through the processing, then the cloned meat would be *fleishig*, at least on a rabbinic level.

Interestingly, SuperMeat's co-founder and co-CEO, Koby Barak, himself a longtime vegan and animal rights activist, said his company's cultured meat will be both kosher and vegan-friendly, and he has the supporters to prove it. "I have spoken to about 10 rabbis and I don't see any problem. It will be kosher and *pareve*," Barak told JTA. "The vast majority of the vegan-vegetarian movement is very supportive, and we thank them for really supporting us."

Conclusion

History has taught that when a product actually hits the public market, religious scholars will carefully assess the status of such products. Gene editing is simply the next, albeit most exciting, new biotechnology that has been developed and is being applied to food science. There is no doubt that the use of gene editing and stem cell technologies will have a huge impact on the food industry. It may be only five to twenty years until we see cloned meat or poultry in the supermarket. Yet, this is not the only

48 *Iggerot Moshe, Yoreh De'ah* 1:37.

case of gene editing changing our food. Besides using these technologies to generate meat, many research companies are using these techniques to produce yeast-derived milk, -wine products, -cheeses, and animal-free eggs, and gelatin.

If these products can be made in a way that they will be less expensive, can mimic the taste of their natural counterparts, and improve our economy, bioresources, and environment, then they should be embraced. Yet their acceptance as part of our regular diet must be through proper understanding of the science through which they are produced and the Halakhah to which they must conform. If the Jewish community is to embrace this advance in food science, it will need rabbis who understand the actual biotechnology. ☙