



90 Reasons to Consider Cellular Agriculture

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90 Reasons to Consider Cellular Agriculture

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PREFACE

Farming animals for products like meat, dairy, and leather have been common globally for over 9,000 years. While animal products have been incredibly positive for society over multiple generations, today they are proving more destructive than beneficial with the rise of factory farming.

After thousands of years depending on animals for agriculture, humanity has finally attained the biotechnological means to supersede this necessity through a new practice called **cellular agriculture**.

This concept of farming identical animal products from cells outside of an animal, without the need for raising a living animal, poses a much-needed solution to factory farming. Cell-ag has the potential to address problems of public health, the environment, and human/animal rights at a remarkable scale, positioning it in an unprecedented class truly capable of revolutionizing the world.

Whether you approach this piece as a skeptic, supporter, or potential consumer, the following is a non-exhaustive list outlining 90 reasons to consider cellular agriculture...



HEALTH



01 No Pathogen Contamination

Since production processes will have robust monitoring systems and minimal human interaction, the risk of common pathogens like Salmonella or E. coli contaminating the food supply is significantly decreased.

MEAT

SEAFOOD

DAIRY

EGGS

02 Lower Global Famine Risk

As we will no longer rely on livestock under cellular agriculture and can safely harvest food during otherwise impossible circumstances like natural disasters, global food security will strengthen, lowering the risk of global famine.

MEAT

SEAFOOD

DAIRY

EGGS

03 No Fecal Contamination

In a 2015 study by Consumer Reports, out of ~500 pounds of beef purchased randomly throughout 26 U.S. cities, 100% of it contained bacteria that signified fecal contamination; cellular agriculture, by decoupling meat from slaughter (when most contamination takes place), would never be at risk for fecal contamination.

MEAT

04 No Added Hormones

The hormones used today in animal agriculture to accelerate animal growth for meat & seafood production would not be needed in a cellular agriculture system.

MEAT

SEAFOOD

05 Longer Shelf Life

Due to contamination-free production methodologies of cellular agriculture, foods can stay safer for a greater duration, ultimately granting a longer shelf life.

MEAT

SEAFOOD

DAIRY

EGGS

06 Feeding the Future

Cellular agriculture can supply the growing demand for animal products, feeding the increasing world population of almost 10 billion by 2050.

MEAT

SEAFOOD

DAIRY

EGGS

HEALTH

07 No Swine or Avian Flu

Without farming animals for animal products, cellular agriculture can eliminate zoonotic outbreaks like the swine and avian flu.



10 Sickle Cell/ Iron-Deficient

Those with sickle cell anemia or other iron-deficient conditions that would otherwise prefer to be vegetarians/vegans as they seek to avoid traditional animal products, will have a viable option to fulfill the nutrient void of heme iron.



08 Geographically Independent

Populations in certain regions of the world with restricted access to animal products due to difficulty in shipping, will be given independence to farm non-native animal products via cellular agriculture through local facilities.



11 No Botulism

The risk of botulism infection from consuming an animal carcass is reduced since cell-based meat and seafood does not require the handling of slaughtered animals.



09 Natural Disasters

In the traditional animal agriculture system, when natural disasters occur, like most recently, Hurricane Florence, farmers will leave their animals behind during evacuations to drown from storm-related flooding; this poses a public health threat since the dead livestock, which attract pathogens and disease, can contaminate that area's water supply. Cellular agriculture, by not using animals, avoids this problem.



12 Un-Natural Disasters

Cellular agriculture, with land-based production facilities instead of the ocean, will circumvent potential disasters like large-scale oil spills in the ocean, which otherwise contaminate the seafood supply.



HEALTH

13 Safe Food in the Nuclear Age

In the case of a large-scale meteoric impact or nuclear war that could block sunlight or contaminate livestock (and ultimately animal products) with radiation, cellular agriculture through secure cell-banks would grant access to radiation-free food.

MEAT SEAFOOD

14 No Antibiotics

The potential adverse health effects of antibiotics in animal products disappear with cellular agriculture, as antibiotics are not used in the production of cellular agriculture foods.

MEAT SEAFOOD
DAIRY EGGS

15 Superbugs Avoided

As antibiotic use is unnecessary in a cellular agriculture system, there no longer exists the risk of antibiotic resistance (Superbugs) developing from the animal protein sector.

MEAT SEAFOOD
DAIRY EGGS

16 Healthier Foods

Without genetic modification, it may be possible to create healthier cellular agriculture products with greater nutritional density like lower fat, and higher protein content.

MEAT SEAFOOD
DAIRY EGGS

17 No Plastic in Food

Without live marine animals who consume plastic in both wild-caught and aquaculture systems, cellular agriculture seafood avoids all plastic contamination.

SEAFOOD

18 No Mercury in Sea Food

Cellular agriculture seafood, without the slaughtering of fish, would be mercury-free.

SEAFOOD



HEALTH

19

Vegetable Contamination

In animal agriculture systems, livestock waste runoff can contaminate water supplies for vegetable farms; issues like this, including a recent national Romaine Lettuce recall linked to a nearby cattle farm, would be avoidable with cellular agriculture.

MEAT

SEAFOOD

DAIRY

EGGS

WILDLIFE PRODUCTS

LEATHER

20

Vegetarian Restricted Allergies

Individuals with allergies to foods such as soy, beans, nuts or gluten that would otherwise prefer to be vegetarians/vegans as they seek to avoid traditional animal products, will be able to consume animal products from cellular agriculture.

MEAT

SEAFOOD

DAIRY

EGGS

21

Biomedical Advancements

Technological advancements in cellular agriculture will be translatable to biomedical fields including regenerative medicine so the research will have utility in multiple domains/sectors.

MEAT

SEAFOOD

DAIRY

EGGS

WILDLIFE PRODUCTS

LEATHER

22

Post-Animal Whey Protein

Cellular agriculture whey protein will offer an animal-based alternative to athletes who would otherwise restrict their supplementation to only plant-based protein sources.

DAIRY

23

No Prion Contamination

Monitored cellular agriculture-based food systems will be able to check for prions, avoiding outbreaks like mad cow disease in meat.

MEAT

24

Hypoallergenic Milk

Cellular agriculture dairy will enable individuals, especially children, with milk allergies the ability to safely consume hypoallergenic milk.

DAIRY

25

Better Taste

Cellular agriculture processes can create foods that taste better since nutritional profiles can be modified positively.

MEAT

SEAFOOD

DAIRY

EGGS



ENVIRONMENT

LAND



26 Cattle

Cellular agriculture bovine meat production processes may require 99% less land.

MEAT

27 Dairy

Cellular agriculture dairy production processes may require 97% less land.

DAIRY

28 Poultry

Cellular agriculture poultry meat production processes may require 66% less land.

MEAT

29 Pigs

Cellular agriculture porcine meat production processes may require 82% less land.

MEAT

30 Seafood

Cellular agriculture seafood production processes may require 55% less land.

SEAFOOD

31 Land Overall

Cellular agriculture production processes overall may require **80% less land.**

MEAT

SEAFOOD

DAIRY

ENVIRONMENT

WATER

32 Cattle

Cellular agriculture bovine meat production processes may require 98% less water.

MEAT

33 Dairy

Cellular agriculture dairy production processes may require 99.6% less water.

DAIRY

34 Poultry

Cellular agriculture poultry meat production processes may require 92% less water.

MEAT

35 Pigs

Cellular agriculture porcine meat production processes may require 95% less water.

MEAT

36 Seafood

Cellular agriculture seafood production processes may require 86% less water.

SEAFOOD

37 Water Overall

Cellular agriculture production processes overall may require **94% less water.**

MEAT

SEAFOOD

DAIRY



ENVIRONMENT

GHG

38 Cattle

Cellular agriculture bovine meat production processes may produce 96% less Greenhouse Gas Emissions.

MEAT

39 Dairy

Cellular agriculture dairy production processes may produce 65% less Greenhouse Gas Emissions.

DAIRY

40 Poultry

Cellular agriculture poultry meat production processes may produce 74% less Greenhouse Gas Emissions.

MEAT

41 Pigs

Cellular agriculture porcine meat production processes may produce 85% less Greenhouse Gas Emissions.

MEAT

42 Seafood

Cellular agriculture seafood production processes may produce 59% less Greenhouse Gas Emissions.

SEAFOOD

43 GHG Overall

Cellular agriculture production processes overall may produce **76% less Greenhouse Gas Emissions.**

MEAT

SEAFOOD

DAIRY



ENVIRONMENT

44 Energy

Cellular agriculture meat production processes may use 45% less energy.

MEAT

SEAFOOD

45 Animal Waste – Land

Without livestock in a cellular agriculture system, the 1.75 billion tons of animal waste produced by animal agriculture will not exist, no longer contaminating underground water and causing organic pollutants.

MEAT

46 Animal Waste – Ocean

Without livestock in a cellular agriculture system, farms with animal waste that can contaminate oceans and waterways will no longer exist, therefore reducing ocean deadzones and algal blooms.

MEAT

SEAFOOD

47 Bottom Trawling

Cellular agriculture can eliminate the need for bottom trawling, an industrial fishing practice where a large net, primarily supposed to catch fish, is dragged across the seafloor scooping up everything in its path, including the unintentional catching of centuries-old coral.

SEAFOOD

48 Fish Blood

Cellular agriculture eliminates the need for aquaculture systems to dump fish blood into public waters which contains viruses that kill natural fish.

SEAFOOD

49 Pesticides/Herbicides

Pesticides and herbicides, otherwise used in animal agriculture, would no longer cause ocean dead zones in a cellular agriculture system.

SEAFOOD



ENVIRONMENT

50 Less Pollution – Land

As cellular agriculture production systems can be organized locally in communities, the pollution from ground transportation and shipping is reduced.

MEAT

SEAFOOD

DAIRY

EGGS

WILDLIFE PRODUCTS

LEATHER

51 Less Pollution – Ocean

As cellular agriculture production systems can be organized locally in communities, polluting fleets, which would otherwise be used for fishing, are reduced.

SEAFOOD

52 Deforestation

Without the high demand for grain production in a cellular agriculture system, the impetus for animal agriculture-related deforestation is eliminated, making way for reforestation efforts.

MEAT

53 Plastic Alternative

Rhino horn created via cellular agriculture can serve as a plastic alternative.

WILDLIFE PRODUCTS

54 Ocean Plastic Contamination

Cellular agriculture seafood would significantly reduce plastic contamination of the oceans as almost half of ocean plastic contamination (46%) comes from the the fishing industry.

SEAFOOD



HUMAN & ANIMAL RIGHTS



55

Farmer Injustice – Physical

Cellular agriculture, by evolving farming to a biotechnological process over a manual one, avoids the poor physical conditions of factory farm employees who have notable amputation risk from machinery.

MEAT

SEAFOOD

DAIRY

EGGS

56

Farmer Injustice – Psychological

Cellular agriculture employees would avoid the poor psychological conditions that factory farm employees endure of a higher risk of developing PTSD from excess slaughter practices.

MEAT

SEAFOOD

DAIRY

EGGS

57

Taxpayer Savings - Recalls

Cellular agriculture systems would save taxpayers money as there would no longer be mass chicken cullings, antibiotic resistance, and product contamination recalls that cost American taxpayers millions.

MEAT

SEAFOOD

DAIRY

EGGS

58

Tanneries Health Risk

Cellular agriculture leather production would avoid the otherwise harmful conditions from tanneries like toxic chemicals that cause long-term health effects including cancer.

LEATHER

59

Seafood Fraud

Seafood produced in a cellular agriculture system will avoid the otherwise common fraudulent practice of '1 in 3 fish being mislabeled', since the system will be under stricter control.

SEAFOOD

60

Seafood Slave Labor

Cellular agriculture has the potential to end slave labor in the seafood industry as it will be able to produce large quantities of seafood without relying on cheap labor.

SEAFOOD

HUMAN & ANIMAL RIGHTS

61 Cheaper Food

With instability and unsustainability in animal agriculture systems, cellular agriculture products, unlike their traditional counterparts, will only go down in price.

MEAT

SEAFOOD

DAIRY

EGGS

62 Animal Killing

Cellular agriculture would eliminate the need to kill over a trillion animals annually for food, as is done today.

MEAT

SEAFOOD

DAIRY

EGGS

63 Animal Suffering

Without the need to raise living animals, cellular agriculture would significantly reduce animal suffering by providing an alternative to factory farming.

MEAT

SEAFOOD

DAIRY

EGGS

64 Poaching

Cellular agriculture-produced wildlife products like rhino horn and ivory may reduce poaching of wildlife due to supply enlargement and increased quality uncertainty.

WILDLIFE PRODUCTS

65 Pet Food

Cellular agriculture pet food creates an alternative for pet owners who do not want to feed their companion animals traditional animal products.

MEAT

66 Overfishing

Without needing to fish for seafood, cellular agriculture avoids overfishing, which is increasingly threatening ocean ecosystems.

SEAFOOD



HUMAN & ANIMAL RIGHTS

67 Seafood Bycatch

By no longer relying on large fishing operations with massive nets, cellular agriculture can eliminate the issue of seafood industry "bycatch", or unwanted fish like dolphins and turtles caught in nets that otherwise come from wild catch systems.

SEAFOOD

68 Endangered Species

Endangered species directly targeted such as sharks, threatened by excessive fishing practices like production of shark-fin soup, would be safe under cellular agriculture systems.

SEAFOOD

69 Biodiversity Loss

Global security of biodiversity increases with cellular agriculture: as deforestation from animal agriculture is reduced, so too is the otherwise threatened biodiversity from habitat loss.

MEAT

SEAFOOD

DAIRY

EGGS

70 Grain to Animals Instead of People

Without needing to raise animals, cellular agriculture avoids the problem of grain being shipped from developing countries, with starving children, to feed to animals in factory farms.

MEAT

SEAFOOD

DAIRY

EGGS

71 Environmental Racism

Cellular agriculture would avoid an animal agriculture-based effect of environmental racism, where individuals who live in lower-economic areas close to livestock operations suffer from manure sprayed over surrounding communities, causing adverse health effects.

MEAT

SEAFOOD

DAIRY

EGGS

72 Product-Specific Wildlife Hunting

Outside of population-controlled hunting, animal products obtained from hunting wildlife, like bears for their gallbladders, could be produced via cellular agriculture.

WILDLIFE PRODUCTS



BUSINESS & ECONOMICS

73 Financial Security

Cellular agriculture offers greater financial security by avoiding problems inherent to animal-based systems like food safety scandals, effects from natural disasters, and costly product recalls.



74 Avoiding Carbon Tax

With its reduced environmental impact, cellular agriculture products will avoid carbon taxes that will otherwise increase the prices of animal agriculture commodities.



75 Product Consistency

With greater control over production methodologies and stricter monitoring of foods, companies can ensure greater product consistency with cellular agriculture systems and avoid fraud.



76 Premium for High Welfare

As studies show consumers may be willing to pay a premium for high welfare animal-based products, this may translate to an analogous interest for cellular agriculture products, as no animals should be harmed in their production.



77 Weather & Climate Independent

Cellular agriculture goods can be produced consistently, independent of the climate of particular regions, so identical animal products can be harvested in countries with hotter or colder climates.



78 Property Values

Cellular agriculture can increase property values since today, intensive animal agriculture facilities with close proximity, devalue homes as much as -6.6% within 3 miles and -88% within 1/10 mile.



BUSINESS & ECONOMICS

79 Taxpayer Savings – Overproduction

In 2016, the United States federal government spent over \$20 million purchasing surplus cheese; cellular agriculture will not be dependent on public policies required for overproduction.



80 Outsource Animal Products

Nations like Singapore and Japan that today must otherwise outsource animal agriculture due to their smaller quantities of domestic land for livestock, can begin to produce animal agriculture products within their own countries.



81 Animal Byproducts

Cellular agriculture can be applied to animal byproducts, which may otherwise develop shortages, like cow horn that comes from the meat industry often used to make jewelry and utensils; should horn become scarce due to the rise of cellular agriculture-produced meat and lack of farmed animals to obtain horn from, cellular agriculture-based techniques could be used to produce sufficient horn to cover existing demand.



82 Taxpayer Savings – Bailouts

Cellular agriculture can decrease government responsibility for distributing federal aid, as it circumvents measures like the Dairy Income Fairness Act and the Dairy Freedom Act, which provide safety nets to farmers through potential bailouts.



83 New Industry, New Jobs

The cellular agriculture industry will produce new biotech-related agriculture jobs.



84 Dairy Waste

There would be less waste of dairy products in a cellular agriculture system, since there is greater product control.



FUTURE & BEYOND



85 Food on Mars

Cellular agriculture grants the ability to feed astronauts more sustainably in space through interplanetary expeditions, as well as on future colonies on Mars.



86 Personalized Future

With personal cellular agriculture production devices, individuals will be able to make custom animal products from their own homes.



87 New Categories of Animal Foods

There may exist a greater diversity of animal products from cellular agriculture, ranging from prospects like dinosaur-based leather to sabre tooth tiger meat.



88 Astronaut Conditions

Cellular agriculture will allow direct control over an astronaut's diet, being able to adjust according to combat-specific medical conditions that may arise during prolonged space travel like muscular atrophy or osteopenia.



89 Food in Space

Unlike standard space food, which requires rigorous examination and storage procedures, cellular agriculture processes carried out in strictly controlled environments will intrinsically minimize risk of exposure to pathogens.



90 New Categories of Animal Materials

Biomaterials from cellular agriculture may offer characteristic benefits of strength and toughness over traditional attire for interplanetary travel or military environments.



SOURCES

- i** https://www.ancient.eu/Animal_Husbandry/
<http://www.cellularagriculture.info>
-
- 1** Stephens, N., Dunsford, I., Di Silvio, L., Ellis, M., Glencross, A. and Sexton, A., 2018. Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in Cellular Agriculture. Trends in Food Science & Technology. Elsevier
<https://justforall.com/en-us/stories/clean-meat#>
-
- 2** <https://tifac.org.in/images/pdf/pub/Cellular%20Agriculture.pdf>
FAO. 2009. The State of Food and Agriculture. Rome, Italy, Electronic Publishing Policy and Support Branch, Communication Division, FAO.
-
- 3** <https://www.consumerreports.org/cro/food/how-safe-is-your-ground-beef>
-
- 4** <http://www.fao.org/3/a-y8705e.pdf>
-
- 5** Stephens, N., Dunsford, I., Di Silvio, L., Ellis, M., Glencross, A. and Sexton, A., 2018. Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in Cellular Agriculture. Trends in Food Science & Technology. Elsevier
<https://justforall.com/en-us/stories/clean-meat#>
-
- 6** <http://www.eolss.net/sample-chapters/C10/E5-01A-04-01.pdf>
-
- 7** Stephens, N., Dunsford, I., Di Silvio, L., Ellis, M., Glencross, A. and Sexton, A., 2018. Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in Cellular Agriculture. Trends in Food Science & Technology. Elsevier
<https://justforall.com/en-us/stories/clean-meat#>
-
- 8** Conversation with Michael Selden
-
- 9** <https://qz.com/1395700/hurricane-florence-drowns-3-4-million-poultry-birds-and-5500-pigs-in-north-carolina/>
<https://www.independent.co.uk/news/world/americas/hurricane-florence-animals-nc-farm-death-tropical-storm-north-carolina-a8547956.html>
-
- 10** <https://newsinhealth.nih.gov/2014/01/avoiding-anemia>
-
- 11** <http://www.cfsph.iastate.edu/Factsheets/pdfs/botulism.pdf>
-
- 12** <https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources/seafood-safety-after-oil-spill.html>
<https://gizmodo.com/5903021/bp-oil-spill-aftermath-eyeless-shrimp-clawless-crabs-and-fish-with-oozing-sores>
-
- 13** <https://www.theglobeandmail.com/life/health-and-fitness/radiation-particles-in-food-are-a-slow-release-health-threat/article4266860/>
-
- 14** Specht, E.A., Welch, D.R., Clayton, E.M.R. and Lagally, C.D., 2018. Opportunities for applying biomedical production and manufacturing methods to the development of the clean meat industry. Biochemical Engineering Journal, 132, pp.161-168. Elsevier
-
- 15** Chang, Q., Wang, W., Regev-Yochay, G., Lipsitch, M. and Hanage, W.P., 2015. Antibiotics in agriculture and the risk to human health: how worried should we be?. Evolutionary applications, 8(3), pp.240-247 Wiley
-
- 16** M.J., 2014. Cultured beef: medical technology to produce food. Journal of the Science of Food and Agriculture, 94(6), pp.1039-1041 Wiley
Smetana, S., Mathys, A., Knoch, A. and Heinz, V., 2015. Meat alternatives: life cycle assessment of most known meat substitutes. The International Journal of Life Cycle Assessment, 20(9), pp.1254-1267. Springer
-
- 17** <http://www.fao.org/in-action/globefish/fishery-information/resource-detail/en/c/1046435/>
<https://finlessfoods.com/about/>

SOURCES

- 18 <http://www.fao.org/english/newsroom/news/2003/19783-en.html>
-
- 19 <https://articles.mercola.com/sites/articles/archive/2018/08/21/e-coli-outbreak-romaine-lettuce-cause.aspx>
-
- 20 Alexandratos, N. and Bruinsma, J., 2012. World agriculture towards 2030/2050: the 2012 revision (Vol. 12, No. 3). FAO, Rome: ESA Working paper
-
- 21 Post, M.J., 2012. Cultured meat from stem cells: Challenges and prospects. *Meat science*, 92(3), pp.297-301. Elsevier
-
- 22 <https://www.forbes.com/sites/lanabandoim/2018/11/16/perfect-day-partners-with-adm-to-make-milk-without-cows/#216f-988c66ca>
-
- 23 Bhat, Z.F., Kumar, S. and Fayaz, H., 2015. In vitro meat production: Challenges and benefits over conventional meat production. *Journal of Integrative Agriculture*, 14(2), pp.241-248. Elsevier
-
- 24 <https://www.ncbi.nlm.nih.gov/pubmed/23622009>
-
- 25 <https://www.cnn.com/2018/03/01/health/clean-in-vitro-meat-food/index.html>
-
- 26 https://scholar.harvard.edu/files/kristophergasteratos/files/nature_the_neomnivore_dash_submission.pdf
<http://science.sciencemag.org/content/361/6399/eaam5324>
-
- 27- https://scholar.harvard.edu/files/kristophergasteratos/files/nature_the_neomnivore_dash_submission.pdf
-
- 43 <https://www.theguardian.com/environment/2018/oct/10/huge-reduction-in-meat-eating-essential-to-avoid-climate-break-down>
-
- 44 <https://www.cnn.com/2018/03/01/health/clean-in-vitro-meat-food/index.html>
-
- 45 <https://www.gao.gov/archive/1999/rc99205.pdf>
Ongley, E.D., 1996. Control of water pollution from agriculture(No. 55). Food & Agriculture Org
Maas, R.P., Smolen, M.D. and Dressing, S.A., 1985. Selecting critical areas for nonpoint-source pollution control. *Journal of Soil and Water Conservation*, 40(1), pp.68-71
-
- 46 <https://www.reuters.com/article/us-usa-pollution-manure-idUSKBN0KQ00F20150117>
Læg Reid, M., Bockman, O.C. and Kaarstad, O., 1999. Agriculture, fertilizers and the environment. CABI publishing.
<https://earthobservatory.nasa.gov/IOTD/view.php?id=44677>
<https://www.nature.com/articles/nature01014>
-
- 47 https://oceana.org/sites/default/files/reports/Trawling_BZ_10may10_toAudrey.pdf
<https://marine-conservation.org/what-we-do/program-areas/how-we-fish/destructive-fishing/>
-
- 48 <https://youtu.be/6PpZQihAqFM>
-
- 49 https://repository.seafdec.org.ph/bitstream/handle/10862/610/9718511490_p023-030.pdf?sequence=1&isAllowed=y
-
- 50 <http://www.un.org/esa/gite/csd/gorham.pdf>
-
- 51 <https://www.transportenvironment.org/what-we-do/shipping/air-pollution-ships>
-
- 52 <https://globalforestatlas.yale.edu/land-use/industrial-agriculture>
-
- 53 http://plastiquarian.com/?page_id=14335
-
- 54 <https://news.nationalgeographic.com/2018/03/great-pacific-garbage-patch-plastics-environment/>
-
- 55 <https://www.theguardian.com/environment/2018/jul/05/amputations-serious-injuries-us-meat-industry-plant>
-
- 56 Dillard, J., 2008. A slaughterhouse nightmare: Psychological harm suffered by slaughterhouse employees and the possibility of redress through legal reform. *Geo. J. on Poverty L. & Pol'y*, 15, p.391

SOURCES

- 57** Gorton, A. and Stasiewicz, M.J., 2017. Twenty-Two Years of US Meat and Poultry Product Recalls: Implications for Food Safety and Food Waste. *Journal of food protection*, 80(4), pp.674-684
-
- 58** <http://www.hazards.org/workingworld/materialdamage.htm>
-
- 59** https://oceana.org/sites/default/files/National_Seafood_Fraud_Testing_Results_Highlights_FINAL.pdf
-
- 60** <https://www.npr.org/sections/thesalt/2018/02/01/582214032/was-your-seafood-caught-with-slave-labor-new-database-helps-retailers-combat-abu>
-
- 61** <https://youtu.be/6PpZQihAqFM>
-
- 62** Broom, D. (1998). Fish welfare and the public perception of farmed fish. In C. Nash & V. Ju-lien (Eds.), *Report Aquavision '98. The Second Nutreco Aquaculture Business Conference Stavanger Forum: Vol. 1998.*
<http://www.fishcount.org.uk/published/std/fishcountchapter19.pdf>
Mattick, C.S., 2018. Cellular agriculture: The coming revolution in food production. *Bulletin of the Atomic Scientists*, 74(1), pp.32-35. Taylor & Francis
-
- 63** Post, M.J., 2012. Cultured meat from stem cells: Challenges and prospects. *Meat science*, 92(3), pp.297-301. Elsevier
<https://www.nature.com/articles/srep44329>
-
- 64** Lenda, M., Skórka, P., Mazur, B., Ward, A. and Wilson, K., 2018. Ivory crisis: Role of bioprinting technology. *Science*, 360(6386), pp.277-277
Fabinyi, M. and Liu, N., 2014. Seafood banquets in Beijing: consumer perspectives and implications for environmental sustainability. *Conservation and Society*, 12(2), pp.218-228.
-
- 65** Chen, K.C., Liao, C.W., Cheng, F.P., Chou, C.C., Chang, S.C., Wu, J.H., Zen, J.M., Chen, Y.T. and Liao, J.W., 2009. Evaluation of subchronic toxicity of pet food contaminated with melamine and cyanuric acid in rats. *Toxicologic Pathology*, 37(7), pp.959-968.
<https://wildearth.com/pages/about>
-
- 66** Jackson, J.B., Kirby, M.X., Berger, W.H., Bjorndal, K.A., Botsford, L.W., Bourque, B.J., Bradbury, R.H., Cooke, R., Erlandson, J., Estes, J.A. and Hughes, T.P., 2001. Historical overfishing and the recent collapse of coastal ecosystems. *science*, 293(5530), pp.629-637
-
- 67** <https://www.worldwildlife.org/threats/bycatch>
-
- 68** Fabinyi, M. and Liu, N., 2014. Seafood banquets in Beijing: consumer perspectives and implications for environmental sustainability. *Conservation and Society*, 12(2), pp.218-228
-
- 69** <https://news.un.org/en/story/2018/05/1010891>
-
- 70** <siteresources.worldbank.org/INTGAT/Resources/GATChapter11.pdf>
www.pnas.org/content/95/5/1989
<http://news.cornell.edu/stories/1997/08/us-could-feed-800-million-people-grain-livestock-eat>
-
- 71** Walker, P., Rhubart-Berg, P., McKenzie, S., Kelling, K. and Lawrence, R.S., 2005. Public health implications of meat production and consumption. *Public health nutrition*, 8(4), pp.348-356
-
- 72** Lenda, M., Skórka, P., Mazur, B., Ward, A. and Wilson, K., 2018. Ivory crisis: Role of bioprinting technology. *Science*, 360(6386), pp.277-277
Lab-grown lungs transplanted into pigs, *Science* 2018
-
- 73** Salin, V. and Hooker, N.H., 2001. Stock market reaction to food recalls. *Review of Agricultural Economics*, 23(1), pp.33-46

SOURCES

- 74** Bonny, S.P., Gardner, G.E., Pethick, D.W. and Hocquette, J.F., 2015. What is artificial meat and what does it mean for the future of the meat industry?. *Journal of Integrative Agriculture*, 14(2), pp.255-263
- Head L, Adams M, McGregor H V, Toole S. 2014. Climate change and Australia. *Wiley Interdisciplinary Reviews: Climate Change*, 5, 175-197.
- Lerner H, Henrik L, Bo A, Stefan G, Anders N. 2013. Stakeholders on Meat Production, Meat Consumption and Mitigation of Climate Change: Sweden as a Case. *Journal of agricultural and environmental ethics*, 26, 663-678.
-
- 75** Hurt, C. "Industrialization in the Pork Industry." *Choices*, Fourth Quarter 1994, pp. 9-13.
-
- 76** https://www.researchgate.net/publication/222157579_Consumer_liking_and_willingness_to_pay_for_high_welfare_animal-based_products
-
- 77** Conversation with Andra Necula
-
- 78** <http://www.crawfordstewardship.org/wp-content/uploads/2018/01/Properties-devalued-by-factory-farms.pdf>
<https://sraproject.org/factory-farms-destroy-communities/>
http://www.myappraisalinstitute.org/webpac/pdf/TAJ2015/TAJ_WI15_p041-050_Feat3-AnimalOperations.pdf
-
- 79** <https://money.cnn.com/2016/08/23/pf/government-cheese-surplus/index.html>
-
- 80** Panagariya, A., 2002, July. Trade and food security: Conceptualizing the linkages. In presentation at the Conference on Trade, Agricultural Development, and Food Security: The Impact of Recent Economic and Trade Policy Reform, Food and Agricultural Organization, Rome, July (pp. 11-12).
-
- 81** Ellis, R., 2013. Tiger bone & rhino horn: the destruction of wildlife for traditional Chinese medicine. Island Press
-
- 82** <https://www.congress.gov/bill/113th-congress/senate-bill/605> <https://www.congress.gov/bill/113th-congress/house-bill/1741>
-
- 83** Audretsch, D.B., Thurik, R. and Thurik, A. eds., 1999. Innovation, industry evolution and employment. Cambridge University Press
-
- 84** <https://www.bloomberg.com/news/articles/2018-10-17/america-is-drowning-in-milk-nobody-wants>
-
- 85** Sychev, V.N., Levinskikh, M.A. and Podolsky, I.G., 2008. Biological component of life support systems for a crew in long-duration space expeditions. *Acta Astronautica*, 63(7-10), pp.1119-1125. Elsevier <https://www.cellag.org/programs/interplanetary-initiative>
-
- 86** <https://www.cellag.org>
-
- 87** https://www.ernaehrungs-umschau.de/fileadmin/Ernaehrungs-Umschau/pdfs/pdf_2018/01_18/EU01_2018_Special_invitro_englisch.pdf
-
- 88** https://www.nasa.gov/mission_pages/station/research/experiments/245.html
https://www.nasa.gov/pdf/64249main_ffs_factsheets_hbp_atrophy.pdf
<https://www.businessinsider.com/humans-could-eat-lab-grown-meat-on-mars-2016-7> <http://bioprinting.ru/en/>
-
- 89** Bonny, S.P., Gardner, G.E., Pethick, D.W. and Hocquette, J.F., 2015. What is artificial meat and what does it mean for the future of the meat industry?. *Journal of Integrative Agriculture*, 14(2), pp.255-263
- Head L, Adams M, McGregor H V, Toole S. 2014. Climate change and Australia. *Wiley Interdisciplinary Reviews: Climate Change*, 5, 175-197.
- Lerner H, Henrik L, Bo A, Stefan G, Anders N. 2013. Stakeholders on Meat Production, Meat Consumption and Mitigation of Climate Change: Sweden as a Case. *Journal of agricultural and environmental ethics*, 26, 663-678.
-
- 90** <https://www.worldwildlife.org/threats/bycatch>

AUTHOR'S NOTE

Reasons Holding True

I'd like to start off by addressing the very likely reality that certain "reasons" will not actualize or may do so in a very different way than outlined. When I started *90 Reasons*, I didn't approach this piece aiming to prove cellular agriculture as an exceptional technology and I still don't today; I believe that will only lead to hyperbolically-induced failure.

I do understand, however, that the future of cellular agriculture is linked with upcoming, intertwining events over the next few decades, so every reason mentioned in this piece ought to be placed under such context, ultimately giving reasonable leniency.

The reality though, is if even half of this list comes true, and those reasons are remotely close to the reality that unfolds, cell-ag will stand as one of the most important advances in human civilization, both for the overall survival of our species, as well as the welfare of sentient beings on our planet.

Direct vs. Indirect Benefits

This paper placed a strong emphasis on "direct" potential benefits of cellular agriculture, in lieu of "indirect" potential benefits. Therefore, the list contains ramifications of a global cellular agriculture system and "direct" consequences of its potential future implementation at scale.

I was disinterested in making claims such as (a) "Cell-ag will aid the healthcare system because it will not cause as much sickness as animal agriculture does presently, which will in turn, save lives" or (b) "Cell-ag will influence immigration since one of the biggest ICE raids in the United States was at a factory farm."

These types of indirect prospects would make this list exponentially larger and while it's not that I don't believe these indirect ramifications to be probable, I believe as the number of assumptions to make indirect claims like these increases, the likelihood of their actual manifestation decreases.

Building the List & Gratefulness to Colleagues

While the cellular agriculture field is still in its infancy, I think most people involved will tell you they discovered this concept in a similar fashion as I did: in awe, and almost disbelief with the quantity of responses to the question, "Why should cell-ag be explored as an alternative to animal agriculture." Particularly those, many of whom I'm grateful for their contributions to this piece, who were dedicating their lives to advancing this before investment from the Bill Gates and Richard Bransons of the world, before the meat industry's interest, before the press, before even one company in this space was formed; these people saw a global revolution on the horizon. I'm grateful and inspired by my colleagues in

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space who, by their tireless efforts, make it abundantly clear to me that cell-ag will be a tremendous force of good this century. Those alone, who assisted with the development of *90 Reasons*, represent over 15 countries speaking to the universality of cellular agriculture's prospects. This list attempts to consolidate such prospects, illustrating why this really is the perfect storm, why cellular agriculture's truly can be a viable solution to the most serious problems that animal agriculture presents.

Intellectual Inspiration

Over 5 years in the making, I derived a lot of intellectual inspiration for *90 Reasons* in trying to address the following questions comprehensively (I hope you see after reading this list, the sort of challenge this became with the breadth of potential for cell-ag):

Why should someone consider cellular agriculture over traditional animal agriculture?

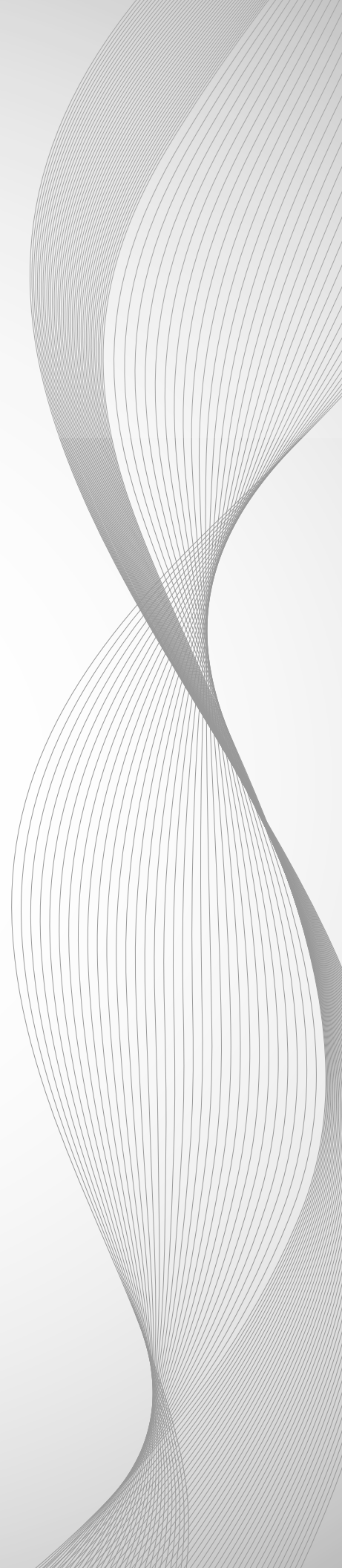
Why should people consider eating meat from cells instead of through the traditional practice of animal slaughter?

Isn't it just weird and unnatural to eat cell-based meat or wear leather/wildlife products from cellular agriculture, instead of from slaughtered or poached animals?

I have a feeling that questions like these will be posed to our field quite often for decades to come, and rightfully so; these are extremely warranted inquiries in thinking about this topic. I hope *90 Reasons* serves as an answer intrinsically to the first and second question above, but as for the third, I personally find this to be quite a valid concern.

While I do understand the sensationalist reaction, (as I have experienced it myself) I hope that anyone who reads *90 Reasons* chooses to evaluate this list on its merits and evidence-based approach. Please understand as the leader of an NGO, I certainly have an interest in wanting cellular agriculture to succeed, but I only support cell-ag insofar as it can demonstrably excel in multiple domains with consumers.

So while cellular agriculture meat may be unnatural, so too are food products like cereal, yogurt, and cheese; eaten by millions daily because of their proven safety and benefits nutritionally. And what about protein powder, literal particulate matter that probably couldn't look or be anymore "unnatural", but again, consumed widely with its perceived health benefits.



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Therefore, if cellular agriculture foods can achieve biomimicry where products taste no different than their animal-based counterparts, and to be clear, I'm not talking about the vegetarian's account of "Oh, this veggie burger (made of plants) tastes EXACTLY like meat"; I'm talking about a large-scale blind taste test with a flawless performance, where not one person can tell the difference from a slaughtered animal. So just selfishly and not considering all the more altruistic reasons in this piece, if it's perfect in taste, safer, nutritionally optimal, it personally becomes tough for me to go against and I think that, at least for me, that gets me off the mental "hump" -- understanding it's the best path forward if it can achieve all these metrics as a food product.

Closing

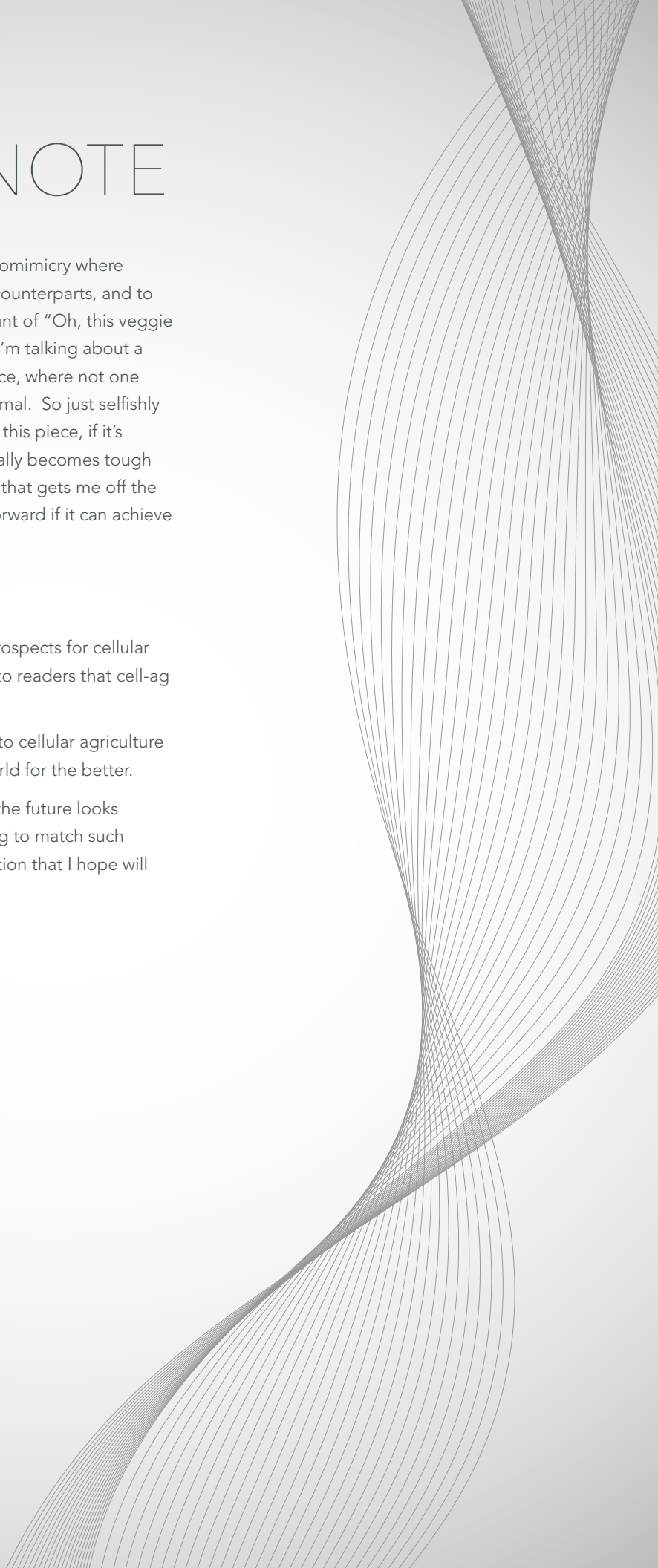
The primary goal of *90 Reasons* is to elucidate the prospects for cellular agriculture, such that strong reasoning is presented to readers that cell-ag is of immense utility to advance.

While much work is still needed, all evidence points to cellular agriculture having unparalleled potential to truly change the world for the better.

At this point, in the early stages of its societal entry, the future looks limitlessly bright for it, and the world is just beginning to match such potential with a deserving level of interest and attention that I hope will continue for many years to come...

For the people, the animals, and the world,

Christopher Hastings



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Arturo Elizondo





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