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3D-Printed Food

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In recent years, controversies regarding 3D printing have been on the rise, with broad questions raised over its regulation and intellectual property.[1] Yet, legal scholars have overlooked the legal issues arising specifically from 3D-printed food. This Article fills that gap as the first to look at the issues surrounding 3D-printed food.

The 3D printer will soon be another kitchen appliance.[2] 3D printers can now print food, ranging from ordinary meals to personalized nutrition and edible growth (i.e., growable food).[3] But with all the new possibilities that foodprinting presents, it also brings along many new challenges. Two of the major challenges to 3D-printed food include safety[4] and labeling.[5]

Under the issue of safety, short-term consumption of 3D-printed food can cause food poisoning or similar harms, whereas long-term consumption can result in permanent changes within the human body. In the short-term, there are two food-poisoning scenarios: (1) one or a few individuals are poisoned from consuming 3D-printed food, or (2) a large number of people are poisoned. Furthermore, long-term modification of eating habits could lead to necessarily permanent changes within the human body in order to adapt to a new diet of consuming strictly 3D-printed food.

Labeling will likely face issues similar to the current Genetically Modified Organism (GMO) labeling debate.[6] For instance, regardless of whether 3D-printed food is safe or not, and assuming consumers cannot easily discern their food's origin, do consumers have the right to know where their food

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1. *See generally* Jasper L. Tran, *The Law and 3D Printing*, 31 J. MARSHALL J. INFO. TECH. & PRIVACY L. 505, 505–07 (2015) (providing a general background on 3D printing and the legal issues beginning to arise).

2. *See* Steven Kurutz, *A Factory on Your Kitchen Counter*, N.Y. TIMES (Feb. 20, 2013), http://www.nytimes.com/2013/02/21/garden/the-3-d-printer-may-be-the-home-appliance-of-the-future.html?pagewanted=all; *see also* Mark A. Lemley, *IP in a World Without Scarcity*, 90 N.Y.U. L. REV. 460, 474–75 (2015) (anticipating a time where the general public will have ready access to 3D printers).

3. *See* discussion *infra* Section I.A.

4. *See generally* discussion *infra* Section II.A.

5. *See generally* discussion *infra* Section II.B.

6. *See, e.g.*, David Alan Nauheim, Comment, *Food Labeling and the Consumer's Right to Know: Give the People What They Want*, 4 LIBERTY U. L. REV. 97, 102–08 (2009) (describing GMOs and the FDA's response to consumer demands for mandatory labeling).

comes from? Other labeling issues could include imitation food and economic adulteration (i.e., misleading consumers).[7] This Article fleshes out such labeling issues through four hypothetical scenarios: (1) a big corporation that foodprints the majority of the package or the entire food package to sell to the mass population, (2) a big corporation that foodprints only a small portion of the packaged food to sell to the mass population, (3) a grocery store that foodprints sushi on sight before packaging it and selling to the local community, or (4) an individual who foodprints a meal at home.

This Article proceeds in three parts. Section I discuses foodprinting's background and implications, including the environmental aspect of 3D-printed food. Section II.A covers safety issues in both the long- and short-term, whereas Section II.B explores labeling issues. Section III briefly concludes.

I. WHAT IS 3D-PRINTED FOOD?

A. 3D-PRINTED FOOD'S ENDLESS POSSIBILITIES

To fully raise a cow for meat, "you have to feed a cow 20,000 gallons of water and 10,000 pounds of grain in its lifetime. Then there's the cost of slaughtering, shipping and packaging. Our grandkids will say, 'that was insane.'"[8] Instead, imagine the possibility of going to one's kitchen to have a 3D-printer print out a customized burger.[9] That will soon be the future, where 3D-printed foods are widely available.

3D-printers resemble the Star Trek[10] Replicator—a machine that can constitute any physical matter out of thin

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7. *See generally* discussion *infra* Section II.B.

8. Linda Federico-O'Murchu, *How 3-D Printing Will Radically Change the World*, CNBC (May 11, 2014, 6:00 AM), http://www.cnbc.com/id/101638702# (quoting Jack Uldrich) (internal quotations omitted).

9. In fact, 3D printing a burger is already happening. *See* Tom Rawstorne, *The Future of Cooking? PRINT Your Dinner: Don't Scoff - But Now 3D printers Can Make Food,* DAILY MAIL (Dec. 27, 2013, 6:27 PM), http://www.dailymail.co.uk/sciencetech/article-2530195/The-future-cooking-PRINT-dinner-Dont-scoff-3D-printers-make-food.html.

10. Star Trek is an American science fiction TV series created by Gene Roddenberry in the 1960s and owned by CBS and Paramount Pictures. *See generally* Máire Messenger Davies & Roberta Pearson, *The Little Program That Could: The Relationship Between NBC and* Star Trek, *in* NBC: AMERICA'S NETWORK 209–22 (Michele Hilmes & Michael Henry eds., Univ. California Press 2007).

air.[11] Current 3D printers function "by setting raw materials into two-dimensional patterns on a platform and gradually raising to stack each layer on top of the next until completion."[12] Similar to the traditional 2D printers,[13] 3D printers need to follow an electronic blueprint to print, called a computer-aided design file (CAD file).[14] "Users can create CAD files by designing them from scratch or scanning an object . . . [and then] edit and share CAD files with others through the Internet."[15]

3D printers can print out anything, from a lithium-ion microbattery[16] to a human kidney,[17] and can print in materials like "extruded or powdered plastic, metal, ceramic, food, cement, wood, and even human cells."[18] 3D printers can print nearly any type of food (hereinafter "foodprinting") imaginable including: (1) food that we currently eat like fruit,[19] pasta,[20]

11. In Star Trek, the Replicators originally synthesized meals on demand, but took on other uses in the later series. *See Star Trek: The Original Series* (NBC television broadcast Sept. 8, 1966–June 3, 1969) (referred to as "food synthesizer"); *Star Trek: The Next Generation* (NBC television broadcast Sept. 28, 1987–May 23, 1994); *Star Trek: Enterprise* (NBC television broadcast September 26, 2001–May 13, 2005) (referring to a Replicator as a "protein resequencer" and a "bio-matter resequencer").

12. Jasper L. Tran, *To Bioprint or Not to Bioprint*, 17 N.C. J.L. & TECH. 123, 133 (2015); Devan R. Desai & Gerald N. Magliocca, *Patents, Meet Napster: 3D Printing and the Digitization of Things*, 102 GEO. L.J. 1691, 1695––96 (2014). For a broad discussion on patents, see generally Jasper L. Tran, *Software Patents: A One-Year Review of* Alice v. CLS Bank, 97 J. PAT. & TRADEMARK OFF. SOC'Y 532, 534–35 (2015) (discussing the validity of software patents); Jasper L. Tran, *Timing Matters: Prior Art's Age Infers Patent Nonobviousness*, 50 GONZ. L. REV. 189, 207–09 (2015) (discussing pharmaceutical patents).

13. *See* Tran, *supra* note 12, at n.46 (citing WARREN CHAPPELL & ROBERT BRINGHURST, A SHORT HISTORY OF THE PRINTED WORD (2000)) (discussing the history of traditional printing).

14. *See* Desai & Magliocca, *supra* note 12; *see also* Lucas S. Osborn, *Of PhDs, Pirates and the Public: Three-Dimensional Printing Technology and the Arts*, 1 TEX. A&M L. REV. 811, 814–15 (2014).

15. Tran, *supra* note 12, at 134 (citing Osborn, *supra* note 14).

16. *See* Ke Sun et al., *3D Printing of Interdigitated Li-Ion Microbattery Architectures*, 25 ADVANCED MATERIALS 4539, 4539–43 (2013). A microbattery is the size of a grain of sand. *Id.*

17. *See* TED-Ed, *Printing a Human Kidney–Anthony Atala,* YOUTUBE (Mar. 15, 2013), https://www.youtube.com/watch?v=bX3C201O4MA (demonstrating a 3D printer using living cells to output a transplantable kidney).

18. Osborn, *supra* note 14, at 813–14.

19. *See, e.g.*, Michael Molitch-Hou, *The 3D Fruit Printer and the Raspberry That Tasted Like a Strawberry*, 3D PRINTING INDUSTRY (May 27,

chocolate,[21] cookies,[22] lollipops,[23] and chewing gum,[24] (2) food that is not found in nature like "edible growth" (i.e., self-contained multi-ingredient bite-size food with living edible plants growing from them),[25] and (3) personalized nutritional food.[26] Foodprinting has advanced so far that it can now treat a renowned chef to a 3D-printed fifty-course meal.[27]

2014), http://3dprintingindustry.com/2014/05/27/3d-fruit-printer-raspberry-tasted-like-strawberry/ (discussing 3D-printed fruit, specifically products that taste like raspberries and strawberries).

20. *See* Michael Molitch-Hou, *Barilla Launches 3D Printed Pasta Contest With Thingarage*, 3D PRINTING INDUSTRY (Aug. 22, 2014), http://3dprintingindustry.com/2014/08/22/barilla-launches-3d-printed-pasta-contest-thingarage/.

21. *See* Michael Molitch-Hou, *Hershey & 3D Systems Unveil New Cutting-Edge Chocolate 3D Printer at CES*, 3D PRINTING INDUSTRY (Jan. 6, 2015), http://3dprintingindustry.com/2015/01/06/hershey-3d-systems-unveil-new-cutting-edge-chocolate-3d-printer-ces/ (discussing 3D-printed chocolate); *see also* Phoebe Li et al., *Intellectual Property and 3D Printing: A Case Study on 3D Chocolate Printing*, 9 J. INTELL. PROP. L. & PRAC. 322 (2014) ("We consider a scenario concerning consumer co-creation resulting from 3D chocolate printing technology developed at Exeter University."). For a general discussion on intellectual property see Jasper L. Tran, *Rethinking Intellectual Property Transactions*, 43 S.U. L. REV. 149, 149–51 (2015).

22. *See Breaking Convention: New 3D Food Printer Makes Edible Cookies*, RT (Jan. 7, 2015), http://rt.com/news/220391-3d-printer-edible-food/ ("[T]he XYZ Printing 3D Food Printer['s] . . . latest model promises to stretch the boundaries of creative food making, as it allows to print any style of uncooked cookies and other dough-based pastries within minutes.").

23. *See* Michael Molitch-Hou, *Stuffhub Teams With Papabubble for Custom Lollipops Made With 3D Printing*, 3D PRINTING INDUSTRY (Feb. 20, 2015), http://3dprintingindustry.com/2015/02/20/stuffhub-teams-with-papabubble-for-custom-lollipops-made-with-3d-printing/ ("3D printables marketplace Stuffhub has now applied 3D printed mold-making to the lollipop business, working with hard candy maker Papabubble . . . to create a custom sweet treat.").

24. *See* Davide Sher, *Don't Burst My Bubble: 3D Printed Chewing Gum Is Coming*, 3D PRINTING INDUSTRY (Feb. 13, 2015), http://3dprintingindustry.com/2015/02/13/dont-burst-bubble-3d-printed-chewing-gum-coming/ ("Through innovation we've created personalised chewing gum by 3D printing technology.").

25. *See* Scott J. Grunewald, *Edible Growth Puts the Fun in 3D Printed Fungus Food*, 3D PRINTING INDUSTRY (Oct. 11, 2014), http://3dprintingindustry.com/2014/10/11/edible-growth-puts-fun-3d-printed-fungus-food/ ("[T]he idea that we can 3D print foods that contain organisms that can allow them to 'cook' while they are in a package waiting to be consumed is especially interesting.").

26. *See 3D Printing Revolution Enters Its 2.0 Phase*, YAHOO! FINANCE (Dec. 30, 2013, 6:59 PM), http://finance.yahoo.com/news/3d-printing-revolution-enters-2-235900208.html (citing Interview with Avi Reichental, former President and CEO, 3D Systems, Inc. (Dec. 30, 2013)) ("[F]ood

Foodprinting fundamentally changes the way we think about food manufacturing and preparation as it could eliminate the entire process, from grocery shopping for ingredients to preparing the ingredients and cooking. In the future, an individual could potentially have a ready-made meal in an instant. No food manufacturing and preparation means: (1) less labor involved, resulting in cheaper food cost, and (2) food becomes more portable—individuals can now make any kind of food in the comfort of their own homes rather than depending on the food manufacturer or restaurants to make a certain type of food.[28]

At first, people might be hesitant to eat 3D-printed food due to their perception that it does not taste as good as traditional food.[29] After a while, most people would likely become desensitized to the new taste so as to not notice the difference. However, unless the choice of access to traditional food has been completely eliminated, the opposite could also hold true: people might get tired of eating only 3D-printed food and revert back to traditional food.

B. IMPLICATIONS OF 3D-PRINTED FOOD

In addition to endless possibilities of foodprinting, 3D-printed foods may bring about many—mostly positive—implications including: (1) solving food scarcity problems, (2) eliminating malnutrition, (3) reducing climate change, (4) eliminating no-longer-necessary businesses, and (5) solving the

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companies and scientists . . . share a vision that, at a certain point in time, some form of 3D printers will be able to print for us personalized nutritional food."). The possibility of personalized nutritional food is rather exciting, as parallel with its cousin—personalized medicine. *See, e.g.*, Jo Handelsman, *Precision Medicine: Improving Health and Treating Disease*, WHITE HOUSE BLOG (Jan. 21, 2015, 5:36 PM), https://www.whitehouse.gov/blog/2015/01/21/precision-medicine-improving-health-and-treating-disease (discussing President Barack Obama's recent launch of "precision medicine initiative" to fund personalized medicine research).

27. *See* Michael Molitch-Hou, *3D Systems Treats Renowned Chef to 3D Printed Absinthe Treat in 50 Course Modernist Meal*, 3D PRINTING INDUSTRY (Aug. 25, 2014), http://3dprintingindustry.com/2014/08/25/3d-systems-treats-renowned-chef-3d-printed-absinthe-treat-50-course-modernist-meal/.

28. Of course, any kind of liquid food, for example, juice or soup, might still require preparation, as current 3D printing technology can only print solid food.

29. The term "traditional food" is used here to distinguish from 3D-printed food.

problem of supplying "food on the go" to astronauts and military personnel. More in-depth details of foodprinting's five implications and ramifications are discussed below.

1. Solving the Food Scarcity Problem

Soon, the world will face a food scarcity problem.[30] The population is growing at an exponential rate[31] and larger populations need more food to sustain their living. While the world's population continues to grow, the available space on Earth remains constant. Unless humans can start living on another planet (as Tesla's CEO, Elon Musk, is working on this with SpaceX[32]), agriculture and traditional farming will likely take a huge environmental toll on the planet.

According to Dr. Jason Clay, Senior Vice President for Market Transformation at the World Wildlife Fund[33]:

> We have to produce as much food in the next 40 years as we have in the last 8,000 . . . . By 2050 we're going to have to produce twice as much food as we do today. We need to find a way to do this more sustainably. The biggest threat to the planet is to continue producing food in a business-as-usual fashion. [34]

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30. *See* Mark Koba, *World May Not Have Enough Food by 2050: Report*, CNBC (Oct. 15, 2014, 12:30 PM), http://www.cnbc.com/2014/10/15/world-may-not-have-enough-food-to-eat-by-2050-report.html (citing a Global Harvest Initiative) ("[W]ith a world population expected to be at least 9 billion people in 2050, the demand for food, feed, fiber and fuel will likely outpace food production if the current rate of output remains the same.").

31. *Human Population: Population Growth*, POPULATION REFERENCE BUREAU, http://www.prb.org/Publications/Lesson-Plans/HumanPopulation/PopulationGrowth.aspx (last visited Feb. 23, 2016); s*ee also* James E. Krier & Clayton P. Gillette, *The Un-Easy Case for Technological Optimism*, 84 MICH. L. REV. 405, 408 (1985) (discussing how "[t]echnological optimism took on its precise meaning, its *exponential* character" as a result of a book "based on the assumption that population, industrial production, and pollution would continue to grow exponentially into the future, as they have in the past").

32. *See, e.g.*, Christian Davenport, *Elon Musk's SpaceX Returns to Flight and Pulls Off Dramatic, Historic Landing*, WASH. POST (Dec. 21, 2015), https://www.washingtonpost.com/news/the-switch/wp/2015/12/21/elon-musks-spacex-pulls-off-dramatic-historic-landing/ (discussing Elon Musk's search for solution to ship people to live on Mars).

33. *See generally Explorers Bio: Jason Clay*, NAT'L GEOGRAPHIC, http://www.nationalgeographic.com/explorers/bios/clay-jason/ (last visited Jan. 1, 2016) (introducing Dr. Clay's background and areas of expertise).

34. Ari Phillips, *What Does 3D Printing Have To Do With Food Scarcity and Climate Change?*, THINK PROGRESS: CLIMATE (Oct. 9, 2013, 2:04 PM), http://thinkprogress.org/climate/2013/10/09/2757331/3d-printing-food/ (quoting Dr. Jason Clay).

In other words, the world needs a solution to the soon-to-be global food scarcity problem, and tackling such a large-scale problem takes time. Luckily, foodprinting is showing strong promise and it could potentially be part of the solution to this global problem.

3D printing makes it easier and faster to produce food. Eliminating the entire manufacturing process of a variety of food allows the manufacturing system to focus more on making ingredients. Once the food production process focuses simply on making the food ingredients that go into the 3D foodprinter, the challenge of making enough to feed the exponentially growing population shifts to the forefront. Yet, solving the food scarcity problem is just the most obvious effect of 3D-printed food; foodprinting brings along many more promises.

2. Eliminating Malnutrition

At his 2015 State of the Union Address, President Barack Obama discussed the availability of personalized medicine in the near future.[35] But how about personalized nutritional food? Avi Reichental,[36] CEO of 3D Systems,[37] and others are working on 3D-printed "personalized nutritional food," although "[i]t may start with simple structures like bars that will include our required daily nutrients and vitamins."[38] Imagine the day when individuals can customize and print each healthy meal in the comfort of their own kitchen without the need for grocery shopping or looking at nutritional labels or logging each of their meals; that day is not too far from now. Individual autonomy in combination with 3D printing nutritious, personalized food menus creates the potential for significant health benefits. This

35. *See* Handelsman, *supra* note 26 ("[A]t his 2015 State of the Union Address, President Obama announced that he is launching a new precision medicine initiative that will help deliver the right treatment to the right patient at the right time.").

36. *See* Michael Molitch-Hou, *Hype Hangover: The Rise and Fall of Avi Reichental*, 3D PRINTING INDUSTRY (Nov. 18, 2015), http://3dprintingindustry.com/2015/11/18/hype-hangover-the-rise-and-fall-of-avi-reichental/ (presenting a narrative of Avi Reichental's career in the 3D printing industry and, particularly, with 3D Systems).

37. *See generally About 3D Systems*, 3D SYS., http://www.3dsystems.com/about-us (last visited Jan. 1, 2016) (explaining that 3D Systems is a company headquartered in South Carolina that engineers, manufactures, and sells 3D printers).

38. *3D Printing Revolution Enters Its 2.0 Phase*, *supra* note 26.

is especially true with the overwhelming prevalence of malnutrition in society today.

According to the World Health Organization (WHO), malnutrition means "undernutrition and overnutrition" or simply "a deficiency of nutrition."[39] Malnutrition can result in obesity,[40] stunted growth,[41] decreased energy levels,[42] weak immune systems,[43] and susceptibility to many other diseases.[44] Currently, obesity is one of the most alarming problems related to malnutrition.[45] The United States is the most obese

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39. MONIKA BLÖSSNER & MERCEDES DE ONIS, WORLD HEALTH ORG., ENVTL. BURDEN OF DISEASE SERIES, NO. 12, MALNUTRITION: QUANTIFYING THE HEALTH IMPACT AT NATIONAL AND LOCAL LEVELS 1 (2005), http://www.who.int /quantifying_ehimpacts/publications/MalnutritionEBD12.pdf ("Many factors can cause malnutrition, *most of which relate to poor diet* or severe and repeated infections, particularly in *underprivileged* populations." (emphasis added)).

40. INT'L FOOD POL'Y RES. INST., GLOBAL NUTRITION REPORT SYNOPSIS: ACTIONS & ACCOUNTABILITY TO ADVANCE NUTRITION & SUSTAINABLE DEVELOPMENT 2 (2015) [hereinafter GLOBAL NUTRITION REPORT SYNOPSIS], http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/129475/filename/129686.pdf; *see, e.g.*, Jennifer Yang, *Malnutrition Not Just a Problem Affecting Poor Countries, Report Shows*, STAR (Sept. 16, 2015), http://www.thestar.com/news/world/2015/09/16/malnutrition-not-just-a-problem-affecting-poor-countries-report-shows.html ("[O]besity, which is a form of malnutrition . . . .").

41. GLOBAL NUTRITION REPORT SYNOPSIS, *supra* note 40; *see, e.g.*, Paul A. Diller, *Combating Obesity with a Right to Nutrition*, 101 GEO. L.J. 969, 979 (2013) ("[M]alnutrition . . . "traditionally manifested itself through conditions like underweight and stunted growth.").

42. Anemia is one form of malnutrition common in women between fifteen and forty-nine years old. GLOBAL NUTRITION REPORT SYNOPSIS, *supra* note 40, at 2–3. "Having anemia may make you feel tired and weak." Mayo Clinic Staff, *Anemia: Overview*, Mayo Clinic, http://www.mayoclinic.org/diseases-conditions/anemia/home/ovc-20183131 (last visited Feb. 24, 2016).

43. GLOBAL NUTRITION REPORT SYNOPSIS, *supra* note 40; *see, e.g.*, Lawrence O. Gostin, *The Resurgent Tuberculosis Epidemic in the Era of AIDS: Reflections on Public Health, Law, and Society*, 54 MD. L. REV. 1, 42 (1995) ("[M]edical conditions that impair the immune system, including malnutrition . . . .").

44. One of the most significant of these diseases is adult diabetes as "1 in 12 adults worldwide have Type 2 diabetes." GLOBAL NUTRITION REPORT SYNOPSIS, *supra* note 40, at 3; *see also* U.N., FOOD & AGRIC. ORG., THE STATE OF FOOD AND AGRICULTURE 73–79 (2013) [hereinafter THE STATE OF FOOD AND AGRICULTURE 2013], http://www.fao.org/docrep/018/i3300e/i3300e.pdf (displaying, both worldwide and by country, the prevalence of conditions associated with malnutrition, including stunting, anemia, vitamin A deficiency, iodine deficiency, and adult obesity).

45. "[S]ome forms of malnutrition . . . such as overweight and obesity, are increasing." GLOBAL NUTRITION REPORT SYNOPSIS, *supra* note 40; *see also*

industrialized country in the world with an obesity rate of 33.9% according to WHO's most recent data.[46] This rate is slightly elevated from the National Bureau of Economic Research (NBER) report in 2013 that 31.8% of Americans were obese and substantially higher compared to approximately fourteen percent in the mid-1970s.[47] The impacts of such a high rate are dramatic; "obesity accounted for 18 percent of deaths among Black and White Americans between the ages of 40 and 85"[48] and healthcare spending on obesity currently "range[s] from $147 billion to nearly $210 billion per year."[49]

While obesity is one of the most prevalent issues, malnutrition as a general matter is becoming more prevalent. In 2014, Global Nutrition Report released a warning that the world is crossing a "malnutrition red line," suffering from too much or too little nutrition.[50] Currently, malnutrition leads to

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Diller, *supra* note 41, at 969 ("The current public-health crisis of obesity . . . ."); Yang, *supra* note 40 ("Rates of obesity . . . increased in all countries between 2010 and 2014 . . . .").

46. An obesity rate of 33.9% is the highest among industrialized nations and ninth highest in the world. *Global Database on Body Mass Index*, WORLD HEALTH ORG. (last updated Feb. 24, 2016) (select from Indicator drop-down "BMI adults % obese (>=30.0)"; then compare all countries "Most Recent" data set). Note that UNICEF characterizes thirty-four countries as "industrialized." *Information by Country: Industrialized Countries*, UNICEF, http://www.unicef.org/infobycountry/industrialized.html (last visited Feb. 24, 2016). *See generally* Lauren Kaplin, *A National Strategy to Combat the Childhood Obesity Epidemic*, 15 U.C. DAVIS J. JUV. L. & POL'Y 345, 351 (2011) ("The high prevalence of overweight and obesity among American children has become a veritable epidemic.").

47. *See* Linda Gorman, *Economic Explanations of Increased Obesity*, NAT'L BUREAU ECON. RES., http://www.nber.org/digest/apr06/w11584.html (last visited Jan. 1, 2016).

48. *Obesity Kills More Americans Than Previously Thought*, COLUM. U. MAILMAN SCH. PUB. HEALTH (Aug. 12, 2013), https://www.mailman.columbia.edu/public-health-now/news/obesity-kills-more-americans-previously-thought (citing a study conducted by researches at Columbia University Mailman School of Public Health on the topic of how obesity impacts mortality); *see also* Goodard Danaei et al., *The Preventable Causes of Death in the United States: Comparative Risk Assessment of Dietary, Lifestyle, and Metabolic Risk Factors*, 6 PUB. LIBR. SCI.: MED., no. 4, Apr. 28, 2009, at 10–15, 23.

49. The State of Obesity, *The Healthcare Costs of Obesity*, TRUST FOR AM.'S HEALTH & ROBERT WOOD JOHNSON FOUND., http://stateofobesity.org/healthcare-costs-obesity/ (last visited Feb. 24, 2016); *see also* THE STATE OF FOOD AND AGRICULTURE 2013, *supra* note 44, at 19.

50. *See* Mark Kinver, *World Is Crossing Malnutrition Red Line, Report Warns*, BBC NEWS (Nov. 13, 2014), http://www.bbc.com/news/science-environment-30005268.

"11% of GDP being squandered as a result of lives lost, less learning, less earning and days lost to illness."[51] Malnutrition affects both poor and developed countries[52] and many countries are struggling to keep the "obesity epidemic" under control.[53]

But fear no more, personalized food holds the promise of fixing all malnutrition problems, assuming no access problem (i.e., everybody has access to adequate supplies of personalized food). Long-term investment in researching personalized food can lead to the possibility of providing each person exactly the nutrition they need, with the nice addition of taste being easily customized to fit each person's desire. That is, each individual would be able to obtain the nutrients they need from 3D-printed food. This would curb the increasing obesity rate currently facing the American population.

Another solution to the malnutrition problem is to print nutrient-rich food that would meet most individual's needs, i.e. his or her suggested daily value.[54] Additionally, foodprinting skips the cooking and/or microwaving steps, which reduces human exposure to carcinogens from charring[55] and toxic radio waves,[56] respectively, when consuming 3D-printed food. Consequently, humans' consumption would become healthier. In short, foodprinting can reduce and possibly eliminate malnutrition once and for all.

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51. *Id.*

52. *See* Yang, *supra* note 40.

53. *See id.*; Kinver, *supra* note 50 ("[N]early every country in the world has crossed a red line on nutrition in terms of it being a serious public health issue.") (quoting Dr. Lawrence Haddad, one of the leading experts who helped compile the "red line" report); Kaplin, *supra* note 46, at 351.

54. *See generally* Phillips, *supra* note 34 (asking if foodprinting technology "holds the potential to produce nutrient-rich food that can be produced locally and on-demand").

55. *Chemicals in Meat Cooked at High Temperatures and Cancer Risk*, Nat'l Cancer Inst., http://www.cancer.gov/about-cancer/causes-prevention/risk/diet/cooked-meats-fact-sheet#q5 (last updated Oct. 19, 2015) (presenting the potential health risks associated with consuming charred meats, which potentially includes increased cancer risks).

56. *Microwave Oven Radiation*, FOOD & DRUG ADM., http://www.fda.gov/Radiation-EmittingProducts/ResourcesforYouRadiationEmittingProducts/ucm252762.htm#Microwave_Ovens_and_Health (last updated Oct. 8, 2010) (discussing potential health impacts resulting from consumer use of microwave ovens).

3. Reducing Climate Change

When everyone begins to 3D-print his or her own food, the process of food production will change drastically. Instead of growing different varieties of food, the agriculture sector will shift its focus to producing different ingredients (and there are not that many required to supply 3D foodprinters). Consequently, agriculture would need to compensate for this change and transform drastically, as well. This transformation would result in a very limited human footprint on the planet and would, in effect, reduce climate change.[57] For example, producing enough chicken, beef, and pork to feed the current population is taking a significant toll on the planet, as these animals consume large quantities of resources and create substantial amounts of waste.[58] Replacing these major food sources with more sustainable options that require much fewer inputs reduces the environmental impact.[59]

This transformation, unfortunately, comes with a downside. If agricultural practices are completely changed or replaced altogether by foodprinters, it will cause a dramatic impact on entire ecosystems. For instance, many species adapted to human's agricultural activities and are heavily dependent on an environment where these activities occur. A change in the current agricultural model would eliminate these dependent species' usual habits, alter the food chain, and, in effect, endanger certain animal species. However, in order to shift to foodprinting, change is inevitable and other animals would likely continue to evolve and adapt in the new

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57. *See* Phillips, *supra* note 34 ("[Foodprinting] could present certain solutions to increasing global food demand that don't put so much strain on natural resources and also significantly reduce food waste [, which] could lead to reduction in greenhouse gas emissions as well.").

58. *See* Tom Foster, *Can Artificial Meat Save the World*, POPULAR SCI. (Nov. 18, 2013), http://www.popsci.com/article/science/can-artificial-meat-save-world. The promise of foodprinting meat-free meal might be the solution to this climate issue. *Id.*

59. *Id.*

> "Beyond Meat[is] a four-year-old company that manufactures a meat substitute made mainly from soy and pea proteins and amaranth. . . . Where one pound of cooked boneless chicken requires 7.5 pounds of dry feed and 30 liters of water, the same amount of Beyond Meat requires only 1.1 pound of ingredients and two liters of water."

Id.

agricultural model.[60] Fortunately, history indicates that equilibrium will eventually return and the strong will survive in the new agricultural landscape to supply ingredients for foodprinting.[61]

4. Eliminating No-Longer-Necessary Businesses

Once people begin to foodprint in the comfort of their own homes, it removes the need for grocery stores, chefs, or associated jobs.[62] Given the ease of ordering goods online and the finite nature of the ingredients needed for foodprinting, people can start ordering foodprinting ingredients in the comfort of their own homes. Once this is the case, grocery stores are no longer needed.

Eventually, when people can prepare their food easily, the culinary profession, including chefs, could go out of business, as well.[63] During and after the complete transition to a world where every house and office has a 3D printer readily available for foodprinting uses, going out to eat food cooked by a chef would be a luxury activity for people with extra time and money.[64]

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60. *See, e.g.*, CHARLES DARWIN, THE ORIGIN OF SPECIES (1864) (discussing the "survival of the fittest").

61. *Id.*

62. In order for everyone to have the ability to foodprint at home, presumably each person will have a 3D foodprinter at his or her home. Once this happens, people will no longer need to go out to buy food or to restaurant if they can print food at home instead. Obviously, stores can still sell products and chefs can still cook, but once the need for them is removed, they would eventually cease to exist. Interestingly, this reduction of labor has nothing to do with robots or artificial intelligence. But the additions of robots and artificial intelligence would further effectuate this reduction of labor. *See, e.g.*, Nils J. Nilsson, *Artificial Intelligence, Employment and Income*, AI MAG., Summer 1984, at 5 (discussing how exploring artificial intelligence would likely affect employment and the distribution of income).

63. Note that eating out is not a necessity, but rather it is something people do as a special activity. When every home and office has a foodprinter, where people can select which food they want every day, their need (and likely desire) to go out and spend money on prepared food would eventually cease to exist. *See, e.g.*, Neil Koenig, *How 3D Printing Is Shaking Up High End Dining*, BCC NEWS (Mar. 1, 2016), http://www.bbc.com/news/business-35631265; *cf.* Molitch-Hou, *supra* note 27 (discussing how a renowned chef was treated with a 50-course 3D-printed meal).

64. Koenig, *supra* note 63 (explaining what the likely effect on high-end dining for customers in the future will be).

5. Solving the Problem of Supplying "Food on the Go"

Food is an everyday need for humans to not only survive but also to have enough nutrients and energy to function.[65] Some professions require "food on the go," which requires a supply of food for people when they are away from permanent structures that would easily supply food. For instance, astronauts need food to survive in space and military personnel need food when they are deployed. Additionally, hikers and backpackers need to bring meals and snacks on their trips. Moreover, other recreationalists, families, and people who travel frequently for work may also want their food readily available without having to packing heavily.

Foodprinting also solves this "food on the go" problem. To produce food, all an individual needs is food ingredients, a 3D foodprinter, and energy.[66] Astronauts and military personnel would benefit the most from this invention,[67] thus the National Aeronautics and Space Administration (NASA) and the military are currently investing heavily in foodprinting.[68] The

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65. *E.g.*, Adam Benforado, Jon Hanson & David Yosifon, *Broken Scales: Obesity and Justice in America*, 53 EMORY L.J. 1645, 1678 (2004) (discussing how the human body has "an acute need for energy" and a "need for food").

66. These are not difficult for a team to carry. Furthermore, the energy for a 3D printer to be used in space can presumably be powered in the same way as other appliances that are used on a spacecraft. *See, e.g.*, Debbie L. King et al., *Mobile Open-Source Solar-Powered 3-D Printers for Distributed Manufacturing in Off-Grid Communities*, 2 CHALLENGES IN SUSTAINABILITY 18, 18–19 (2014) (discussing the possibilities associated with solar-powered 3D printers); *The Smallest, Battery Powered 3D Resin Printer Launches on Kickstarter, $189 for Early Birds*, 3DERS.ORG (Oct. 16, 2014), http://www.3ders.org/articles/20141016-the-smallest-battery-powered-3d-resin-printer-launches-on-kickstarter.html (discussing specifications of "the first battery powered 3D Resin Printer"); TE Halterman, *Battery Backup Power Inc. Will Keep Your 3D Printer on Track When the Power Goes Out*, 3DPRINT.COM (Aug. 28, 2015), http://3dprint.com/92299/battery-backup-power-inc/ (discussing the benefits of back-up power for 3D printers).

67. Of course, foodprinting would likely face a few problems before being readily available for space use. Current research on battery-powered 3D printers would help the effective implementation of foodprinter for uses in space. *See id.* Furthermore, although both astronauts and military personnel have specific needs, what their needs have in common is food supply, which the technology of foodprinting could solve completely.

68. *See* Loura Hall & Brian Dunbar, *3D Printing: Food in Space*, NASA, http://www.nasa.gov/directorates/spacetech/home/feature_3d_food.html (last updated July 28, 2013); Jane Benson, *3-D Food*, 2 ARMY TECH. 22, 22 (July–Aug. 2014), https://www.dodmantech.com/ManTechPrograms/Files/Army/Army_Technology_Mag_3D_Printing.pdf ("'It is revolutionary to bring 3-D printing into the food engineering arena. . . . To see in just a couple of years

ability to print food on demand would reduce cost,[69] eliminate food waste (by foodprinting only what a person needs to eat),[70] and provide nutrients-rich food with longer expiration dates than the current three-year shelf life of a Meal Ready-to-Eat (MRE).[71]

II. ISSUES WITH 3D-PRINTED FOOD

Once 3D-printed food is nicely integrated into the U.S. economy, two major issues will soon face foodprinting: safety and labeling.

A. SAFETY ISSUES

In terms of safety, 3D-printed food would likely raise both short-term and long-term issues. It is natural for people to be wary about such a dramatic change in food production. For instance, one expert in the area of 3D printing, Mr. Tim Shinbara from the Association of Manufacturing Technology, echoes these concerns, particularly in terms of 3D-printed food:

> Even if it technically works, should we be doing it? If we start creating food instead of growing or harvesting it—that gets a little scary. At a molecular level, does your body accept something that's been artificially and genetically manufactured? Even if it looks the same under a microscope, what will it do to you over 10, 20 years?[72]

While the timeline for widespread 3D-printed food is unknown, safety concerns like Mr. Shinbara's are already prevalent. Some of these main concerns are discussed below.

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how quickly it is advancing, I think it is just going to keep getting bigger and bigger in terms of its application potential.'") (quoting U.S. Army Natick Soldier Research, Development and Engineering Center's Lauren Oleksyk); Interview by *Army Technology* with Dr. Thomas Russell, Director of Army Research Laboratory, in 2 ARMY TECH. 4, 4–5 (July–Aug. 2014), https://www.dodmantech.com/ManTechPrograms/Files/Army/Army_Technology_Mag_3D_Printing.pdf (discussing the research vision for 3D printing uses in the military); *see also* Tran, *supra* note 1, at 505–06 ("NASA[] has been investing in 3D printing, and the military has recently jumped on the bandwagon to fund projects for 3D-printed food . . . .").

69. Benson, *supra* note 68, at 22.

70. *Id.*

71. *Id.*

72. Federico-O'Murchu, *supra* note 8 (quoting Tim Shinbara, Technology Director of the Association of Manufacturing Technology).

1. Short-Term: Food Poisoning

3D-printed food, though new, is still food after all. Thus, relevant statutes will still apply and presumably govern 3D-printed food,[73] unless the government implements new statutes in the future that specifically regulate 3D-printed food. Historically, legislation always progressed slower than technologies[74] so, unsurprisingly, there is currently no statute directly regulating 3D-printed food.

Short-term consumption of 3D-printed food could give rise to adulterated food, which is prohibited, and could result in food poisoning issues.[75] On the regulatory end, adulterated food is typically regulated under food safety inspection, falling under the shared jurisdiction of the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA).[76]

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73. FDA has jurisdiction to regulate foods if they are "articles used for food or drink for man" or if they are "components of any such article." 21 U.S.C. § 321(f) (2012). This definition is not based on the manufacturer's intent for an article to be food or a component, and so applies to anything that in function is used as a food. United States v. Tech. Egg Prods., Inc., 171 F. Supp. 326, 328 (N.D. Ga. 1959) ("The term 'food' . . . must be read in such a way that it includes, but is not limited to items which are unfit to be consumed. The test for determining whether an item is a food under the Act can not be one of intended use.").

74. *See, e.g.*, Jasper L. Tran, *Press Clause and 3D Printing*, 14 NW. J. TECH. & INTELL. PROP. 75, 77 (2016) ("Technology is progressing at an extraordinary speed . . . . The government has attempted to regulate many emerging technologies . . . .").

75. The sale of adulterated food is prohibited and can result in seizure of products, injunctions against sale, and criminal prosecutions. *See* 21 U.S.C. § 331 (listing prohibited acts); *id.* at § 334 (providing for seizure); *id.* at § 332 (providing for injunctions); *id.* at § 333(f) (providing for criminal penalties); *id.* at § 335b (providing for civil penalties). Practitioners should note that the courts have interpreted criminal liability under this statute to have no *mens rea* component. United States v. Park, 421 U.S. 658, 672–73 (1975) ("The Act does not . . . make criminal liability turn on awareness of some wrongdoing or conscious fraud."); United States v. Dotterweich, 320 U.S. 277, 283–85 (1943).

76. *See* Gretchen Goetz, *Who Inspects What? A Food Safety Scramble*, FOOD SAFETY NEWS (Dec. 16, 2010), http://www.foodsafetynews.com/2010/12/who-inspects-what-a-food-safety-scramble/#.Vnw0YhorJZ0 ("Two government agencies, the U.S. Department of Agriculture and the Food and Drug Administration, share most of the responsibility of food safety inspection . . . . Take eggs, for example. The FDA inspects shelled eggs, while the USDA is responsible for egg products, including liquid, frozen and dehydrated eggs. The FDA regulates the feed chickens eat, but the laying facility falls under USDA jurisdiction . . . . Open-faced sandwiches are inspected by the USDA; closed-face, the FDA. The FDA

The relevant statute for adulterated food is the Federal Food, Drug, and Cosmetic Act of 1938,[77] which prohibits both the adulteration of food and the sale of adulterated food.[78] A food is "adulterated" if: (a) "it bears or contains any poisonous or deleterious substance which may render it injurious to health"[79]; or (b) "it bears or contains any added poisonous or added deleterious substance . . . that is unsafe."[80] Food poisoning, excluding food allergies, must necessarily result from either definition (a) or (b), containing "poisonous or added deleterious substance."[81]

In the event of food poisoning, the FDA would prosecute the food-production companies and, if food poisoning resulted in deaths, the case could become a criminal prosecution. FDA enjoys complete discretion in deciding whether to prosecute or not; its decision is not subject to judicial review as the statute precludes it.[82]

In any event, there are two possible food poisoning scenarios from the perspective of the victim(s): (1) one or a few individuals are poisoned from consuming 3D-printed food, or (2) a large number of people are poisoned. As both scenarios involve liability for different actors, each is discussed in detail below.

a. Scenario 1: Food Allergy

Scenario 1 covers the situation when one or only a few individuals were poisoned from consuming 3D-printed food. Scenario 1 is very unlikely and would only happen in the case of specific individual's food allergy. FDA currently enforces food allergy issues by requiring the disclosure of major food

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regulates bagel dogs, while the USDA is in charge of corn dogs."); *see also* 21 U.S.C. § 374 (authorizing FDA inspections).

77. *See generally* The Federal Food, Drug, and Cosmetic Act of 1938, 21 U.S.C. §§ 301–92 (2015). Section 346 includes a safe-harbor for food additives that could otherwise cause a food to be adulterated, but such an analysis would not be relevant to 3D-printed food unless FDA provides by regulation a tolerance level for poisonous or deleterious additives that might occur in 3D printed food. *See* 21 U.S.C. § 346.

78. 21 U.S.C. § 331(a)–(c).

79. 21 U.S.C. § 342(a)(1) (2015).

80. *Id.* at (a)(2)(A).

81. *Id.* at (a)(1)–(2)(A).

82. *See* Heckler v. Chaney, 470 U.S. 821, 835 (1985) ("The [Federal Food, Drug, and Cosmetic] Act's enforcement provisions thus commit complete discretion to the Secretary to decide how and when they should be exercised.").

allergens on labels or labeling, with the failure to do so enforceable as a misbranded article, rather than an adulterated article.[83] Current law only requires labeling or disclosure of eight major food allergens (milk, egg, fish, shellfish, tree nuts, wheat, peanuts, soybeans).[84]

In the case of an allergy from 3D printing ingredients, labeling of all traces of ingredients should be mandated to shift the responsibility to each individual consumer. This way, other parties involved in the foodprinting process could disclaim liability.[85] Each individual is presumably responsible for selectively not consuming food to which they are allergic. Once all the ingredients are clearly labeled, allergic reactions can be prevented. In the event of mislabeling that results in food poisoning from allergies, the party responsible for the mislabeling would take the blame for the damages stemming from food poisoning, as the damages were foreseeable.

b. Scenario 2: Batches of Ingredients Containing Contaminations

Scenario 2 occurs when one or more batches of foodprinting ingredients contain contaminated substances. Scenario 2 is the more likely occurrence of the two scenarios. In the event this happens, the parties responsible for the contamination bear the liability.

If the parties lack incentive to do a nationwide recall—for example, to avoid reputational harm to the corporation's business—the government should intervene and mandate a

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83. *See* Food Allergen Labeling and Consumer Protection Act of 2004, Pub. L. 108-282, 118 Stat. 905 (2004) (codified in various sections, but principally at 21 U.S.C. § 343(w)).

84. *See* U.S. FOOD & DRUG ADMIN., U.S. DEP'T HEALTH & HUMAN SERVS., GUIDANCE FOR INDUSTRY: QUESTIONS AND ANSWERS REGARDING FOOD ALLERGENS, INCLUDING THE FOOD ALLERGEN LABELING AND CONSUMER PROTECTION ACT OF 2004 (EDITION 4); FINAL GUIDANCE (Oct. 2006), http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/ucm059116.htm ("Congress designated eight foods or food groups as "major food allergens." . . . . Although there are other foods to which sensitive individuals may react, the labels of packaged foods containing these other allergens are not required to be in compliance with FALCPA.").

85. As discussed above, government agencies enjoy total discretion in deciding to prosecute cases of food poisoning, thus are immune from liability. *See* discussion *supra* Section II.A.1.

recall[86] of the ingredients containing poisonous or deleterious substances.

There are only a few parties involved in the foodprinting process: the foodprinter manufacturer, the ingredient manufacturer—which could be one or more parties—and the shipping company or retailer that sold the foodprinter/ingredients to each individual. Given the limited number of players in the foodprinting process, the chance of food poisoning decreases as fewer parties means fewer chances for error. Depending on if the contamination occurs either early or late in the process, the number of food poisoning cases would likely be either very large or very small, respectively.

Based on the specifics of the foodprinting process, health insurance could easily handle food poisoning in the event of either a small or a large number of food poisoning cases.[87] However, a recall protocol must be in place or significant class action product liability lawsuits against the responsible party (i.e., foodprinter manufacturer or ingredients manufacturer) are possible.

In the event it is impossible to identify the party responsible for the contamination, strict liability can apply to the makers, either the foodprinter manufacturer or ingredients manufacturer, or the retailer—all of which are product providers, not service providers—via *res ipsa loquitur*.[88] Thus, the defendants would be jointly and severally liable to the poisoned plaintiff(s) as the manufacturers, rather than the victim(s), should bear the burden of apportionment in terms of blame and compensation.[89]

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86. FDA's authority to issue a recall is broad. 21 U.S.C. § 350*l*.

87. *See generally*, Hot Stuff Foods, LLC v. Houston Cas. Co., 771 F.3d 1071, 1075–76 (8th Cir. 2014) (denying coverage under an "Accidental Product Contamination" policy for a food company's voluntary recall due to mislabeling that did not pose a public health hazard, but noting arguendo a recall that did pose a public health hazard would be covered).

88. The doctrine of *res ipsa loquitur* is generally applied in situations where negligence clearly occurred and (1) the defendant had exclusive control of the instrumentality during the relevant time, and (2) the plaintiff shows that he was not responsible for the injury. RESTATEMENT (SECOND) OF TORTS § 328D (1965). The court is not required to infer negligence and a presumption is not created; *res ipsa loquitur* merely permits the fact finder to infer negligence from the facts. *Id.; see, e.g.*, Commercial Molasses Corp. v. New York Tank Barge Corp., 314 U.S. 104, 112–13 (1941).

89. *See generally* Summers v. Tice, 33 Cal. 2d 80, 82–83 (Cal. 1948) (describing a situation in which two negligent hunters fired but only one bullet hit the plaintiff. Where the requirement of actual proof under these facts

2. Long-Term: Changes to the Human Body

There is a high possibility that long-term modification of eating habits to strictly consuming 3D-printed food could result in permanent changes to the human body. The interesting question becomes: who is responsible for this change? If the change is "good"[90]—for example, the human body readily accepts 3D-printed food and, over time, rejects traditional food because of human's adaptation and evolution process[91]—there is no harm done. However, if the change is "bad"—for instance, the human body rejects all 3D-printed food, there is a legal safety issue.

Given the relative novelty of 3D-printed food, there have not been any long-term, well-controlled population studies of the foodprinting industry. Without such a study,[92] it is hard to make a legal conclusion. Currently, no foreseeable legal issues with long-term consumption of 3D-printed food exist, at least not yet. Although no one knows the answer without anecdotal evidence, preventative measures and a well-defined compensation scheme for the injured victims—in the event that only some, not all, people who have consumed 3D-printed food develop health complications—are needed.

But assuming there is a problem with modification of eating habits—for instance, if everyone who has consumed 3D-printed food developed cancer—then similar guidance as above could apply (i.e., holding the responsible parties strictly liable), which in this case is likely the ingredients manufacturer.[93] Otherwise, to prove negligence, the causation element would be impossible to prove,[94] given a long time has passed and many

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would result in a harsh result on an innocent victim, courts have traditionally held the defendants to be jointly and severally liable for the cause-in-fact, considering the injury to be indivisible as a matter of policy). *Id.* at 84–85.

90. Of course, "good" or "bad" here are subjective as some might argue that it is actually not "good" if the human body rejects traditional food because, for instance, ingredients for 3D-printed food may become scarce.

91. *See, e.g.*, DARWIN, *supra* note 60 (discussing the "survival of the fittest").

92. Note that the absence of evidence does not imply a lack of consequences; it merely means that no conclusion can yet be drawn.

93. *See* discussion *supra* Section II.A.1.b.

94. *See, e.g.*, Univ. of Texas Sw. Med. Ctr. v. Nassar, 133 S. Ct. 2517, 2525 (2013) ("In the usual course, this standard requires the plaintiff to show 'that the harm would not have occurred' in the absence of—that is, but for—the defendant's conduct.") (citing RESTATEMENT OF TORTS § 431 cmt. a (negligence); § 432(1) & cmt. a (same); § 279 & cmt. c (intentional infliction of

variables (in addition to the long-term dietary adaption of consuming only 3D-printed food) could cause the change. Because of the lack of research in this area—besides the legal issues discussed in the preceding paragraphs—many of the potential legal issues in terms of the safety of consuming 3D-printed food are still unclear.

B. LABELING ISSUES

The more interesting legal issue comes from the labeling aspect of selling 3D-printed food. This issue would likely end up before the U.S. Supreme Court if government agencies, likely the FDA, do not have clear guidelines for labeling 3D-printed food.[95]

3D-printed food will likely face the same labeling challenges as GMO food.[96] GMO food faces the same problem as foodprinting with respect to unknown long-term effects.[97] As a result, people are scared of consuming GMO food and demand clear labeling, arguing for the right to know.[98] Although people might be skeptical of consuming 3D-printed food at first, once it is proven safe and is an appealing (i.e., tasty) food alternative, it might be the future of our food supply.

Assuming current law applies to 3D-printed food, two current provisions of the Federal Food, Drug, and Cosmetic Act of 1938 favor clear labeling.[99] First, 3D-printed food could

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bodily harm); § 280 (other intentional torts); RESTATEMENT (THIRD) OF TORTS: LIABILITY FOR PHYSICAL AND EMOTIONAL HARM § 27 & cmt. b (2010)).

95. Note that in a 2014, the U.S. Supreme Court held that that a statutory private right of action under the Lanham Act is not precluded by regulatory provisions of the Food, Drug, and Cosmetic Act. *See* POM Wonderful LLC v. Coca-Cola Co., 134 S. Ct. 2228, 2241 (2014).

96. For a discussion of GMO, see generally A. Bryan Endres, *"GMO:" Genetically Modified Organism or Gigantic Monetary Obligation? The Liability Schemes for GMO Damage in the United States and the European Union*, 22 LOY. L.A. INT'L & COMP. L. REV. 453, 454–62 (2000).

97. *Id.* at 456 ("Many consumers, especially in Europe, oppose genetically modified food because they suspect the food will prove unhealthy in the long run.").

98. *See, e.g.*, Nauheim, *supra* note 6, at 98–102.

99. For a discussion on the FDA's regulation of drugs, see generally Eric Lindenfeld & Jasper L. Tran, *Beyond Preemption of Generic Drug Claims*, 45 SW. L. REV. 241, 241–42 (2015) (discussing liability of generic drug manufacturers); Eric Lindenfeld & Jasper L. Tran, *Prescription Drugs and Design Defect Liability: Blanket Immunity Approach to the Increased Costs and Unavailability of Prescription Medication*, 64 DRAKE L. REV. 111, 111–14 (2016) (discussing liability associated with prescription drugs); Jasper L. Tran

qualify as imitation food.[100] For instance, in the case of processed apple juice vs. real apple juice, processed apple juice must be labeled "concentrated," which itself is an imitation of freshly squeezed apple juice. Labeling otherwise would be misleading. Second, there might also be an issue of economic adulteration (i.e., food fraud) for 3D-printed food.[101] When real food would likely cost more to produce than 3D-printed food, selling 3D-printed food without clear labeling would be cheating the consumers of their money if both naturally produced food and 3D-printed food are sold at the same price. This analysis is more applicable to cases where a large portion of (or a majority of) the packaged food was 3D-printed. For instance, without clear labeling, consumers who presumably cannot tell the difference between real food and 3D-printed food—by taste or sight—might initially think they were purchasing real food when in fact what they got was 3D-printed food. On the other hand, this analysis is less applicable to the cases where only traces of 3D-printed food (as ingredients) were used to prepare food.[102]

The labeling requirement based on the current law will be demonstrated through four hypothetical scenarios. Note that the labeling issue is only relevant during the transition time from a society with no 3D-printed food to one with exclusively 3D-printed food. The point of being able to foodprint is that eventually the world resembles Scenario 4, where everyone can simply foodprint a meal at home without buying any packaged food from the grocery store.[103] But until then, the labeling issue is relevant in the transition period where Scenarios 1–4 are applicable.[104]

& Derek Tri Tran, *(De)Regulating Neuroenhancement*, 37 U. LA VERNE L. REV. 101, 105–13 (2015) (discussing liability of using neuroenhancing drugs).

100. For the statute on imitation (misbranded) food, see 21 U.S.C. § 343(c) (2015) ("A food shall be deemed to be misbranded . . . . If it is an imitation of another food, unless its label bears, in type of uniform size and prominence, the word "imitation" and, immediately thereafter, the name of the food imitated.").

101. For the statute on economic adulteration, see generally 21 U.S.C. § 342(b) (2015) ("Absence, substitution, or addition of constituents").

102. This view presumes that consumers accept traces of 3D-printed food (as ingredients) in their food overall, thus clear labeling is not required. Obviously, those who called themselves "purists" would have a problem with this. *See* discussion *infra* Part II.B.2 and note 108.

103. *See generally* discussion *infra* Part II.B.4.

104. *See* discussion *infra* Part II.B.1–4.

All scenarios assume that 3D-printed food is not recognizable to the average individual who cannot discern from its appearance that the food was 3D-printed. If 3D-printed food was obvious from its looks, there would be no need for labeling and the call for labeling 3D-printed food would be moot. Even if the 3D-printed food was only obvious to some people but not others, labeling would still be an issue.

1. Scenario 1: Foodprinting the Majority of the Package Food to Sell to the Mass Population

Scenario 1 covers the situation when a big corporation foodprints the majority of the package or the entire food package to sell to the mass population. This scenario is a strong case for labeling, given the majority (or the entire amount) of food was foodprinted. A similar argument for the consumers in the GMO debate applies here: the consumers have the right to know what type of food they are eating.[105]

2. Scenario 2: Foodprinting a Small Portion of the Package Food to Sell to the Mass Population

Scenario 2 covers the situation when a big corporation foodprints only a small portion of the packaged food to sell to the mass population. This is a weaker case for labeling as the results can go either way depending on the proportion of 3D-printed food in each package. If the amount of 3D-printed food was too small, say less than one percent, labeling would not be necessary. But if the amount of 3D-printed food was larger but not large enough to be considered the majority under Scenario 1 (i.e., thirty percent labeling), labeling is warranted. In short, a certain threshold would need to be set as the labeling cutoff.[106] This is similar to labeling trans fat in food nutritional value, where less than 0.5 gram of trans fat needs not be labeled (i.e., leaving trans fat value at zero percent).[107]

However, traces of 3D-printed food (less than one percent) could still scare "purists," i.e., those who prefer to consume

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105. *See, e.g.*, Nauheim, *supra* note 6, at 98–102.

106. *Cf.* 21 C.F.R. § 101.9(c)(2) (2015) (requiring trans fat to be clearly labeled after a certain threshold).

107. The Nutrition Labeling and Education Act of 1990 requires that a product label disclose the amount of trans fat per serving by rounding to the nearest 0.5 gram, thus less than 0.5 gram of trans fat can be labeled as 0 gram or 0%. 21 C.F.R. § 101.9(c)(2) (2015).

wholly natural food.[108] Ethically, labeling is still needed for these health-conscious people, a similar requirement in the ongoing "organic" versus "regular" food debate.[109] Furthermore, as discussed above, to avoid liability for causing allergic reactions in some people, the best practice would be to label all 3D-printed food as "3D-printed" and shift the responsibility to the consumers to determine what food to put in their bodies.[110] Thus, when in doubt, it is better to label as "3D-printed."

3. Scenario 3: Foodprinting in Front of the Customers Before Selling

Scenario 3 covers the situation where, for example, a grocery store foodprints sushi on-site before packaging it and selling to the local community. This is a weaker case than Scenario 2, where some of the consumers saw the food was 3D-printed, and the rest of the consumers know—from common knowledge—that the food was 3D-printed. However, a small amount of customers might not know that the food was 3D-printed if it was their first time trying the food or they bought the food after business hours when the foodprinting was over.

This case is a toss-up, with arguments leaning strongly to the side of no labeling. The customers with actual knowledge of seeing the foodprinting process would not need any labeling, as they would already be on notice. However, the customers without actual knowledge would arguably want labeling. Given how the scenario portrays how the foodprinting process is done in front of most customers, scenario 3, on balance, favors no labeling.

4. Scenario 4: Foodprinting a Meal at Home

Scenario 4 covers a situation where an individual foodprints a meal at home. This is a clear case for no labeling,

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108. *Cf.* Adam Thierer, *Technopanics, Threat Inflation, and the Danger of an Information Technology Precautionary Principle*, 14 MINN. J.L. SCI. & TECH. 309, 315–16 (2013) (discussing how the public is scared of emerging disruptive technologies).

109. *See, e.g.*, Jason J. Czarnezki, *The Future of Food Eco-Labeling: Organic, Carbon Footprint, and Environmental Life-Cycle Analysis*, 30 STAN. ENVTL. L.J. 3, 14 (2011). The debate is similar because, for example, (1) some people are allergic to even just a trace amount of ingredients that can cause them allergy, such as gluten; and (2) people should feel safe with the food they consume, not scared of unknown ingredients they might not know about.

110. *See* discussion *supra* Part II.A.1.a.

because the individual did not even buy packaged food, thus, there is no package to label.

III. CONCLUSION

At the 2016 *Minnesota Journal of Law, Science & Technology* symposium, the keynote speaker, Candice Ciresi, described the 3D-printing of food as "a first world problem, not a third world solution."[111] This characterization notes that the current foodprinting technology is using food-based—not chemical—materials to assemble food products in novel shapes rather than generating new food as a potential solution for solving famines or food scarcity. However, she also mentioned that scientists are working on the possibility of creating food from chemical compounds,[112] which could enable foodprinting to generate new food where scarcity exists, thus serving as a potential "third world solution."

This Article discusses both the first world legal problems that will arise during attempts to commercialize 3D-printed food and also looks to the future when 3D-printed food may become part of a third world solution. This Article analyzed these first world legal issues by starting with the premise that the 3D printer may become the fundamental daily appliance in every household, where people can foodprint and customize each meal in the comfort of their own homes. Safety issues will require legal professionals to creatively adapt existing FDA regulations over food safety and food allergens to a world where food manufacturers and food consumers are one-in-the-same. Labeling issues are currently in flux, and lawyers should watch the litigation over GMO foods to understand how the courts will consider freedom to label and freedom from labeling issues surrounding 3D-printed food. Although these two big legal issues will soon face the foodprinting technology—and are the primary focus of this Article—they are not the only issues associated with 3D-printed food. Other issues will likely include, but are not limited to, intellectual property, policy, and

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111. Candice Ciresi, Former General Counsel, Stratasys, Keynote Address at the University of Minnesota Law School Journal of Law, Science & Technology Symposium: Disruptive Innovation: Legal Concerns in 3D Printing (Mar. 4, 2016) (video available at https://www.youtube.com/watch?v=znAhzZxwDwk).

112. *Id.*

ethics, that will arise as 3D-printed food rolls out in larger commercial settings.