

Beyond Artificial: Breaking Binary Labeling for Synthetic Biology Food Products

Published October 19, 2016

UC Davis 2016 iGEM Team; Alexis Caligiuri—Human Practices Student Lead

Abstract

Stemming from the empirical data we have collected from our stakeholder interviews and IRB reviewed survey, as well as in depth governmental and science policy research, we have developed some policy considerations for food labeling for the products of genetic engineering globally, with an examination of extremely recent regulatory changes in the United States as a text case. We propose that the terms “natural” and “artificial” have become virtually meaningless as applied to many products of Synthetic Biology but especially to our specific project as it complicates, expands, and encounters a web of concerns around the meanings of these terms. We propose incremental and exponential movements toward a wealth of labels that allow accurate information to consumers and open a realistic dialogue about the current human food system.

Background: Industry

Cyantific represents seminal research demonstrating that an entire new class of food dyes can be created to address the need for vibrant “natural” dyes. This need is created by a processed food industry that is seeking to appeal to the desires of consumers to provide more “natural” foods without fundamentally altering practices—these companies continue to add food dye to products, often to appeal to children.¹ The companies are responding to specific consumer health worries. Some studies have shown that there may be a link between hyperactivity in children and their consumption of artificial dyes.² These studies are not necessarily conclusive or unanimous³, and reporting on the shift from artificial to natural colorings emphasizes that the focus is

¹ Burrows, J.D., A. (2009), *Palette of Our Palates: A Brief History of Food Coloring and Its Regulation*.

Comprehensive Reviews in Food Science and Food Safety, 8: 394–408. doi:10.1111/j.1541-4337.2009.00089.x

² McCann, et al. (2007) "Food additives and hyperactive behaviour in 3-year-old and 8/9-year-old children in the community: a randomised, double-blinded, placebo-controlled trial." *The Lancet* 370 (9598):1560-1567. doi: 10.1016/S0140-6736(07)61306-3.

³ <http://www.businessinsider.com/facts-about-natural-and-artificial-flavors-2014-1> (focusing on petroleum based and nature-identical flavors, concluding that all are non-toxic as currently regulated).

consumer desire rather than actual risk.⁴ Nevertheless, this study was considered sufficiently demonstrative of danger that it was cited by the National Health Service for the United Kingdom,⁵ recommending that, “If your child shows signs of hyperactivity or attention deficit hyperactivity disorder (ADHD), eliminating some colours from their diet might have beneficial effects on their behaviour.” This warning focuses on yellow dyes that come from the same coal-tar (processed petroleum) family as Blue #1—the most difficult dye to recreate.

The industry is seeking a dye that reflects the same wavelength as Blue #1, and can be produced with in a manner that would be considered “natural.” MARS put out a press release explaining “...We’ve committed to removing artificial colors from all of our human food products. It’s part of our ongoing commitment to meet evolving consumer preferences while taking advantage of new technologies and scientific information.”⁶ Other companies such as Nestle⁷ and General Mills⁸ have made similar statements, demonstrating an industry wide shift⁹ for processed foods.

⁴ <http://www.prnewswire.com/news-releases/mars-incorporated-to-remove-all-artificial-colors-from-its-human-food-portfolio-300216158.html>

⁵ <http://www.nhs.uk/conditions/food-additive-intolerance/Pages/Introduction.aspx>

⁶ MARS, Inc. Global About Us, Color Policy

(<http://www.mars.com/global/about-us/policies-and-practices/color-policy>)

⁷ “Nestlé’s[...] commitment to remove artificial flavors and certified colors in our chocolate candy brands is an important milestone,” said Doreen Ida, president, Nestlé USA Confections & Snacks. “We know that candy consumers are interested in broader food trends around fewer artificial ingredients. As we thought about what this means for our candy brands, our first step has been to remove artificial flavors and colors without affecting taste or increasing the price.” Nestle USA Press Release; February 17, 2015

<http://www.nestleusa.com/media/pressreleases/nestl%C3%A9-usa-commits-to-removing-artificial-flavors-and-fda-certified-colors-from-all-nestl%C3%A9-chocolate-candy-by-the-end-of-20>

⁸ “In recent years, we’ve heard that artificial ingredients aren’t what you are looking for in your bowl.

So today, we’ve announced that we are committing to remove artificial flavors and colors from artificial sources from the rest of General Mills cereals.” General Mills Blog; June 22, 2015

<http://blog.generalmills.com/2015/06/a-big-commitment-for-big-g-cereal/>

⁹ More companies making similar pledges can be found here: http://www.huffingtonpost.com/entry/11-companies-that-plan-to-remove-artificial-flavors-before-2019_us_55b6a777e4b0074ba5a5d327

Background: Regulatory Framework

It is clear that, under many international regulatory regimes, for example, in the US, according to the labeling policies of the Food and Drug Administration which sets the standards for American food safety and requirements for labeling and distribution, that by adopting our dyes, these food companies could market their products as containing "all natural" colors.¹⁰ This would allow such companies to phase out an older generation of artificial colorants. Currently, because although our dye originates in the lab, they are grown in biological vectors and the compounds exist in nature, unlike fully artificial processed petroleum coal-tar dyes which are small molecules.¹¹ This practice is not in place for artificial colorings outside of some market for beta-carotene,¹² but such synthetic biology products have become prominent sources for nature-identical flavorings.¹³ Moreover, under recent US federal legislation, the Cyantific dye products would not be labeled as GMO products in the US, at least, because the legislation explicitly requires labeling only for products which contain transgenic DNA.¹⁴ Since our dye is extracted protein, there will not be any DNA in the final product, and therefore foods containing this dye will not be labeled as products of bioengineering. For all fifteen member states of the European Union as well as Norway and Iceland, where "natural-identical" exists as a regulatory labeling category for food additives, these proteins would fall under such a category, rather than "artificial."¹⁵ Hence, international food companies could market foods colored with our dyes as

¹⁰ <http://www.fda.gov/AboutFDA/Transparency/Basics/ucm214868.htm>

¹¹ 21 C.F.R. 101.22(a)(4)(c) (2016).

(<https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr=101.22>)

¹² Ringe + Kuhlmann, Products: Nature Identical Colorings;

http://riku.com/en/Products/Nature_Identical_Colourings.html

¹³ <http://www.evolva.com/vanillin/>

¹⁴ 7 U.S.C. § 1639b (Establishment of national bioengineered food disclosure standard. Effective: July 29, 2016)

¹⁵ http://ec.europa.eu/food/fs/sfp/flav_index_en.html; See previous discussion of active labels for

fully natural or natural-identical, depending on country, and this would be completely accurate and legal, as far as existing legislation is concerned.

Questions: Consumer Expectations

According to a survey conducted by Consumer Reports in the United States in 2015, shoppers prefer natural, and are willing to pay more for natural products if they meet expectations.¹⁶ Furthermore, Consumer Reports explains that “consumers demand more standards for natural and organic labels on packaged and processed foods,” and they expect that the labels mean, “...that no pesticides, artificial ingredients, artificial chemicals, or genetically modified ingredients were used; an even greater amount of consumers feel that this labeling *should* indicate this.”¹⁷ Currently, the FDA has no definition of natural; the agency made a request for comments in May 2016, and has yet to report any findings.¹⁸ In Europe, public opinion (70% of respondents) similarly demonstrates a perception that food which is genetically modified or the product of a genetically modified organism “is fundamentally unnatural” according to a 2010 Eurobarometer poll.¹⁹ According to a survey done by a 2015 iGEM team from NTU Singapore, respondents approved of genetic modification in theory, but were not interested in buying such products.²⁰ Although these surveys inquired about genetic engineering

¹⁶ https://www.consumerreports.org/content/dam/cro/magazine-articles/2016/March/Consumer_Reports_Natural_Food_Labels_Survey_2015.pdf “While nearly 4 out of 10 consumers currently do not buy food labeled natural, among this group, three quarters would buy food labeled natural if the label met their expectations. Many Would Pay More for ‘Natural’ if It Met Their Expectations While many (62%) consumers already buy food labeled natural, the overwhelming majority (87%) of these consumers would pay even more for natural food if the label met their expectations.”

¹⁷ *Id.*

¹⁸ <http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm456090.htm>

¹⁹ Eurobarometer by the European Commission (Europe, 2010) (http://ec.europa.eu/public_opinion/archives/ebs/ebs_341_en.pdf)

²⁰ 2015 iGEM team NTU (Singapore, 2015) ([http://2015.igem.org/wiki/images/8/8c/Public_Perception_towards_Genetically_Modified_Organisms_\(GMO\)_in_Singapore.pdf](http://2015.igem.org/wiki/images/8/8c/Public_Perception_towards_Genetically_Modified_Organisms_(GMO)_in_Singapore.pdf)) “It can be concluded from the result that although the general public in Singapore holds a generally positive attitude towards the safety of GMO products but they are less willing to purchase such products.

and natural-ness, none had questioned around this border—what about products, like ours, which were created through biological tissue, and were not genetically modified in order to be improved? How might we take a Science and Technology Studies (STS) approach and examine the boundaries between natural and artificial?²¹

Methods

We adopted a few different disciplinary methods in order to best answer these questions. We interviewed industry stakeholders—people who invest in synthetic biology companies, as well as scientists at Monsanto, MARS, and UC Davis, and small businesspeople who needed natural blue dyes for their cupcakes. For several individuals contacted, this included visiting the workplace and being immersed in their practice. For others, these interviews were over coffee, or even more causally over the phone. We fully understood what the business-facing elements of our project needed to look like. However, public acceptance has been a concern in synthetic biology since the field's inception,^{22,23} and in order to answer new questions that our nature-identical dye brought forth, we needed to examine a crucial public. We created a survey to find out how people at local farmers' markets in Central and Northern California felt about nature-identical food products—and whether it made a difference to them whether a dye was biologically

They have also shown a more cautious and conservative attitude towards GMF than other GMO products. In addition, general public also thinks more efforts should be made to better inform and publicize about GMOs" (p. 6)

²¹For more exploration around areas where facts are so disputed and contested (and in some ways irrelevant to the broader concerns of scientists, activists, and other publics) that their role in the conversation becomes advisory rather than decisive, see Bruno Latour (2004). "Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern." *Critical Inquiry* 30(2): 225-248. I would like to take to task the notion that "natural" can be defined, scientifically. Instead, I posit that "natural" is an arbitrary line drawn by all participating in the discourse, and that the perception of natural offered by our survey respondents is as valid as any other. To see this matter of concern play out in narrative form, please see the Techno-Moral Scenario presented on the Seeing Blue: Scenarios for Synenergene page of the wiki.

²² Rabinow, Paul, and Gaymon Bennett. *Designing Human Practices: An Experiment with Synthetic Biology*. 2012. Print.

²³ Marris, C. (2015). "The Construction of Imaginaries of the Public as a Threat to Synthetic Biology." *Science as Culture* 24(1): 83-98.

generated or chemically synthesized. We submitted our protocols to the Institutional Review Board and received an exemption determination—ensuring that we were held to high standards of research ethics in our human subject intervention. We collaborated on question development and shared results with UC Santa Cruz.

Results

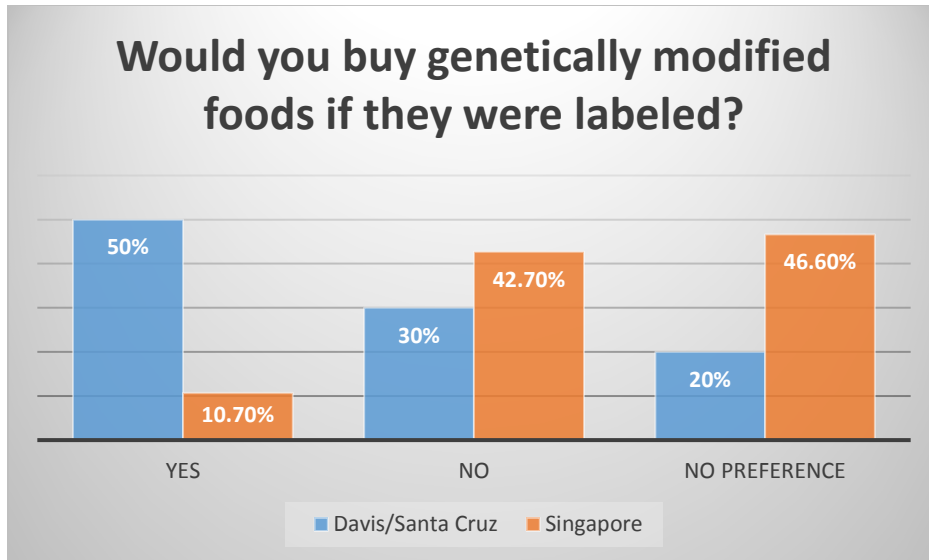
We found that GMO researchers and SynBio investors both felt that the current regulatory scheme did not represent reality. One of the Monsanto researchers emphasized that genetically modified foods were our main hope for food security as the world population exponentially increases, and that any measures that would increase consumer confidence in this necessary process, up to and including labeling, were critical in the coming century. Former CalGene scientist Dr. Martineau was strongly in favor of labeling as a way to ensure that the industry focused on genetic alterations that would improve the crops not only in terms of yield but also in terms of traits that matter to the consumer—and that would ensure industry accountability and would consider and prioritize wildlife.²⁴

Our survey showed that consumers preferred labelling as well—and not just for the purpose of avoiding purchasing. At many points in the surveys, participants said that they did not have enough information to offer an opinion. One respondent explained, “I would buy GMO labelled foods “if I understood more about this complex process.” These findings correspond to the results of many other studies around the world, for example recall the 2015 Consumer Reports survey which found that for Americans, the overwhelming majority would pay even more for natural food if the label met their expectations,²⁵ and that an earlier Eurobarometer poll

²⁴ For more information about Dr. Martineau’s scientifically informed concerns about traditional and emerging biotech practices, check out her blog: <https://biotechsalon.com/about/>

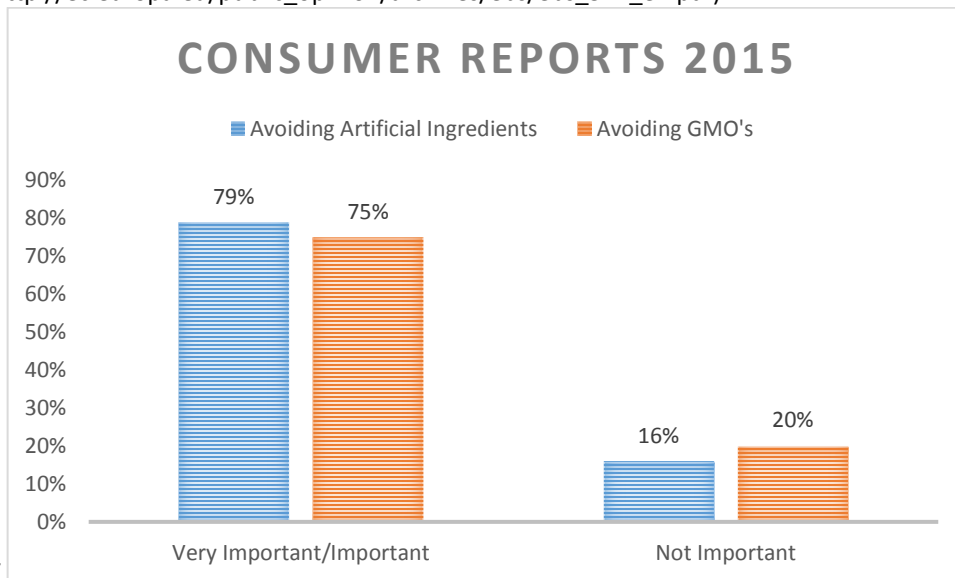
²⁵ https://www.consumerreports.org/content/dam/cro/magazine-articles/2016/March/Consumer_Reports_Natural_Food_Labels_Survey_2015.pdf

showed that a high proportion, believed that genetically altered food is fundamentally unnatural.²⁶ While avoiding GMO's was a high priority for many participants in the American survey, avoiding artificial ingredients was found to be important to even more people.²⁷ Survey data from 2015 NTU Singapore's iGEM team offers very intriguing comparative data to our survey, though they found a public more unfriendly to GMO labeling (Figure 1).



(Figure 1)

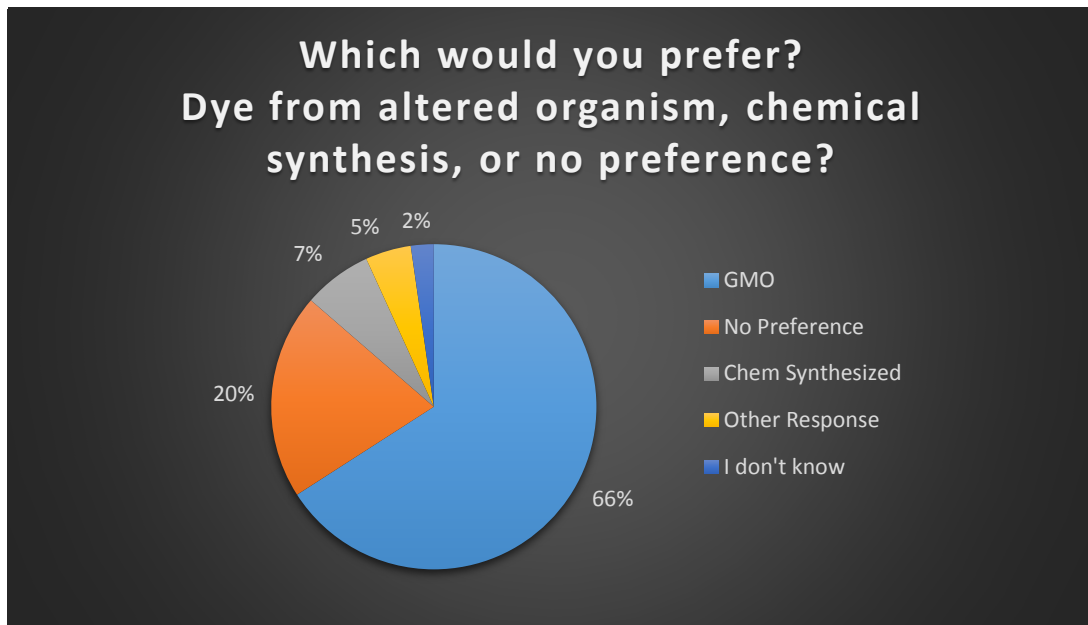
²⁶ Eurobarometer by the European Commission (Europe, 2010) (http://ec.europa.eu/public_opinion/archives/ebs/ebs_341_en.pdf)



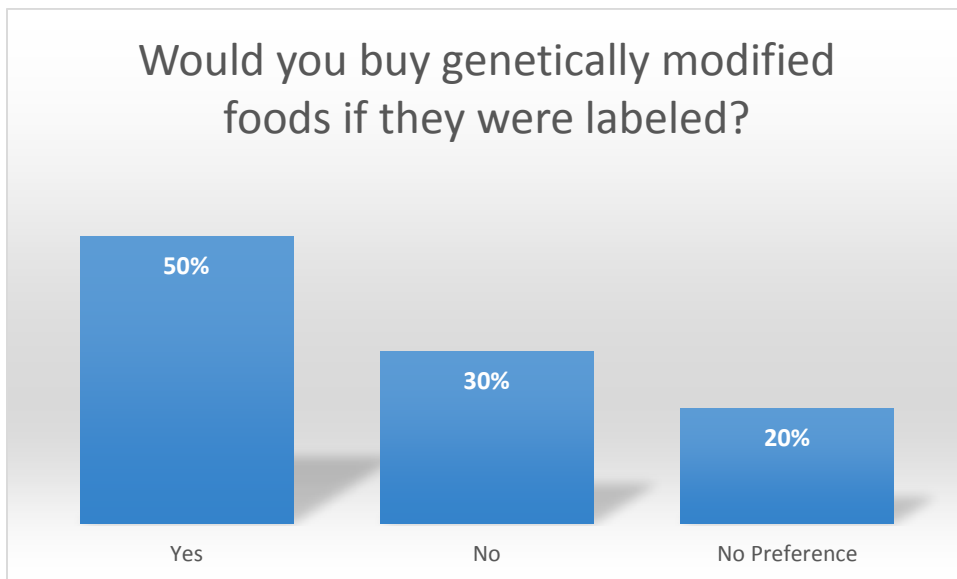
²⁷

https://www.consumerreports.org/content/dam/cro/magazine-articles/2016/March/Consumer_Reports_Natural_Food_Labels_Survey_2015.pdf

Analysis of Combined Results from Davis and Santa Cruz Farmer's Markets:



(Figure 2)



(Figure 3)

Conclusions

These charts demonstrate that labeling may not be a catastrophe. Intense lobbying²⁸ and argument surrounding bioengineered food labeling legislation has created an adversarial environment for all involved. A UC Davis Ph.D student in Plant Biology, Don Gibson,²⁹ was one subject interviewed during the course of this research. He was active in science policy circles in 2012, when a ballot measure for the State of California, Proposition 37, which would have required “Mandatory Labeling of Genetically Engineered Food” was being voted on.³⁰ One portion of the proposed legislation required that “Prohibited labeling or advertising such food as ‘natural.’”³¹ He was passionate about sensible science policy, and participated in the “GMO debates” in a few public forums, and expressed frustration that some people refused to be swayed by science. While his understanding of nature is nuanced by his significant experiences working with plants, and especially his current projects regarding tomato plants, he felt that he could not persuade those who refused to see the reason of science.

Our team takes a different approach to the public that is not instantly swayed by declarations of science. We want to briefly address the lack of trust between the food companies and the consumers, especially as it relates to our project. The history of litigation for misleading advertising is profound with regard to food dyes, and parallels can be drawn between the colorant

²⁸ https://www.opensecrets.org/lobby/issue_spec.php?id=FOO&year=2016 See all forms related to S. 764 (which became the Bioengineered Food Standard) and H.B. 1599, a precursor with similar backers. Interestingly, the Grocery Manufacturer’s Association filed one of the citizen petitions that lead to the FDA opening its’ call for comments regarding “natural” labeling, and also spend significant amounts of money on lobbying efforts with an earlier draft of S. 764 which would have compelled the FDA to establish a definition of natural. See generally <https://www.opensecrets.org/news/2015/07/three-times-as-much-agribusiness-money-on-average-for-house-members-voting-to-bar-gmo-labeling/>.

²⁹ Further information about his research can be found here:
bioscinet.ucdavis.edu/Students/Profiles/Display/10508

³⁰ [https://ballotpedia.org/California_Proposition_37,_Mandatory_Labeling_of_Genetically_Engineered_Food_\(2012\)](https://ballotpedia.org/California_Proposition_37,_Mandatory_Labeling_of_Genetically_Engineered_Food_(2012))

³¹ *Id.*

fraud charges³² and genetically modified foods marketed as natural fraud claims, such as *In re ConAgra Foods, Inc.*,³³ where consumers sued ConAgra on the grounds that their label read 100% natural, which they believed indicated that the cooking oil was not made from genetically modified organisms. Perhaps there is no greater showing of a lack of faith in the food producer than class action fraud litigation. The decision *In re ConAgra* determines that the plaintiffs are not only a certifiable class, but have an actionable claim—that their understanding of natural in relation to food has been so disrespected that the shopper may be entitled to monetary compensation for such damages. Litigation risks are especially concerning to our team as we move forward, as our project sits at the nexus between food colorants (an older subject of fraud charges) and “natural” genetically modified food products.

Because of this fundamental incommensurability between the many understandings of what it means to be natural, we do not support the continuation of the binary of natural or artificial that is currently delineated in FDA guidelines. Instead, we hold that the most ethical and most positive action that could be taken at this juncture is to open up the labeling spectrum. An intermediate step for the United States would be to consider Europe’s trinary identification scheme by incorporating the label of nature identical. In our survey, out of the people who responded with a definitive answer, 85.7% of respondents felt that “Nature-Identical” was a good label. By integrating this new language into the way that we identify products, we can begin to

³² Burrows, J.D., A. (2009), *Palette of Our Palates: A Brief History of Food Coloring and Its Regulation*. *Comprehensive Reviews in Food Science and Food Safety*, 8: 394–408. doi:10.1111/j.1541-4337.2009.00089.x

³³ *In re ConAgra Foods, Inc.*, 908 F. Supp. 2d 1090 (C.D. Cal. 2012). “The complaint generally asserts that each plaintiff saw that Wesson Oils were marketed as ‘100% Natural,’ purchased the product because of the representation, and would not have purchased it but for the representation. Each plaintiff was purportedly damaged by paying for a product that was 100% natural, and receiving a product ‘that was genetically engineered in a laboratory, and had its genetic code artificially altered to exhibit not natural qualities.’”

really make progress building trust between consumers and producers. But just adding this option is not enough.

French theorist Jacques Derrida is considered the first to truly deconstruct and critically analyzed the binary logic and system of "oppositions through which western culture and philosophy are thought." Feminist Technology theorist Donna Haraway harnesses this preoccupation with binary existence in order to radically break down socially-constructed and harmfully constraining gender boundaries.³⁴ Then she makes a turn towards a broader societal understanding that is intrinsic within the field of synthetic biology (a cyborg field, if you will), and which we have had to grapple with. Haraway insists that humans and machines are so codependent that we must understand ourselves as cyborgs. The boundary between natural and artificial, in her life as in our protein, has become unintelligible. The border has become so fuzzy that it is no longer of use.

At this point, labeling anything as genetically modified is not specific enough to have meaning. As all iGEM participants are well-aware, there are many methods of genetic engineering. Our work is comfortably transgenic in nature, edited through "Golden Gate" protocol, but this is descended from tomatoes altered by agrobacteria, and is in turn the ancestor of modern techniques like CRISPR. Even more broadly, radiation induced mutagenesis and selective breeding represent human intervention in evolution. Certainly the fruits of these procedures are not currently labeled. What we call for is a re-envisioning of how we categorize and describe how a food comes to be. Once we expand our vocabularies to include a multiplicity of origins, only then can the consumers truly understand how their foods arrive on their plates.

³⁴ Donna Haraway, "A Cyborg Manifesto: Science, Technology, and Socialist Feminism in the Late Twentieth Century," in *Simians, Cyborgs and Women: The Reinvention of Nature* (New York; Routledge, 1991)

Therefore we conclude that, although it would be entirely possible to market these dyes as natural, enabling international food companies to fulfill their public promises to shift to all natural ingredients, our research suggests it would not be the most prudent nor the most responsible approach. The expansion of ways of expressing the sources of food products is a long term policy recommendation for governments globally, even those that already acknowledge categories beyond natural and artificial.

As for producers, we propose that, if the food industry were to take up our protein dyes, that a more elaborate labeling mechanism to indicate the synthetic biology nature of these nature-derived dyes, or some other means of providing thorough information, would be the responsible and ethical thing to do -- *even though it would not be required by existing legislation*. This approach would benefit science, industry, and society, by building trust and providing better alternatives in the market than most of the current artificial or naturally harvested colorants. Our dye is safe by design, unlike coal-tar predecessors, and is precision engineered to the needs of industry, as well as more sustainable for the environment and the public in terms of resource allocation and arable land use. But its' impact does not stop at coloring food—from the questions that our dye creates, we can see the insufficiency of our current way of thinking about genetically engineered technologies. To maintain standards of responsible research and innovation then it must be extended beyond the laboratory and into the practices of industrial development and marketing.