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# Shaping Public Discourses of Nature: Biological Mutation in the American Press, 1820-1945

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## Introduction

In the early 1970s, the American public witnessed what would later be called the "genetic engineering revolution" prompted by the emergence of biotechnologies which allowed for molecular manipulation of the DNA. The revolution spawned into existence a range of new scientific fields; for instance, medical biotechnology with products such as engineered vaccines or synthetic human insulin, as well as applications in areas such as gene therapy, or in vitro fertilization. A different facet of this revolution linked biotechnologies to agriculture, in particular, to the development of genetically modified (GM) food crops.[1] While the first patents for such products were granted to American companies in the early 1980s, the commercialization of genetically modified organisms (GMOs) occurred around the mid-late 1990s. The application of the recombinant DNA (rDNA) technology to modify plant genomes and develop products such as herbicide-resistant soybeans or pest-resistant potatoes, became an issue of public controversy which culminated during last years of the century and continued unabated into the next. "Not even the disasters at Three Mile Island and Chernobyl were sufficient to produce such heavy and effective political pressure to prohibit or further regulate a technology, despite the evident fact that uncontained radioactivity has caused the sickness and death of very large numbers of people, while the dangers of genetically engineered food remain hypothetical", wrote Richard C. Lewontin in a 2001 review of four volumes documenting the then-recent development, regulation, and reception of genetically modified organisms in the United States.[2]

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1 For the history of the biotech industry and development of genetic technologies, see Nicolas Rasmussen, *Gene Jockeys. Life Science and the Rise of the Biotech Enterprise*. Baltimore: Johns Hopkins University Press, 2014; Paul F. Lurquin, *The Green Phoenix: A History of Genetically Modified Plants*, New York: Columbia University Press, 2013; Sally S. Hughes, *Genentech. The Beginnings of Biotech*, Chicago: University of Chicago Press, 2011; Melinda Cooper, *Life as Surplus: Biotechnology and Capitalism in the Neoliberal Era*, Seattle: University of Washington Press, 2008; Eric J. Vettel, *Biotech: The Countercultural Origins of an Industry*, Philadelphia: University of Pennsylvania Press, 2006; Sally S. Hughes, "Making Dollars Out of DNA: The First Major Patent in Biotechnology and the Commercialization of Molecular Biology, 1974-1980" *Isis* 92.3 (2001): 541-75; Arnold Thackeray (ed.), *Private Science. Biotechnology and the Rise of Molecular Sciences*, Philadelphia: University of Pennsylvania Press, 1998; Sheldon Krimsky, *Biotechnics and Society: The Rise of Industrial Genetics*, New York: Praeger, 1991; Martin Kenney, *Biotechnology: The University-Industrial Complex*, New Have: Yale University Press, 1988.

2 Richard C. Lewontin, "Genes in the Food!" *The New York Review of Books* 48.10 (21 Jun 2001): 84.

Ever since Herbert Boyer and Stephen Cohen's development of the gene splicing technique in 1973, the American mass media reported on risks associated with biotechnology, evoking "images of Frankenstein monsters and Andromeda-like strains spreading incurable disease".[3] The uncertainty regarding the safety and morality of the experimental creation of transgenic organisms had at the time extended to the American scientific community. Urged by the Stanford University biologist Paul Berg, in 1974 the National Institutes of Health established the Recombinant DNA Advisory Committee (RAC) to assess the risks involved in rDNA research. The international conference of scientists held the following year in Asilomar, California, catapulted the topic to the forefront of science news. Only sixteen journalists were allowed to cover the meeting where scientists would establish the guiding principles for managing rDNA molecules that would serve as a standard reference to the advisory committee for future genetic experiments. In 1976, another moratorium was issued against universities which had conducted rDNA research, subsequently lifted as the result of the deliberations undertaken by a local citizen panel in Cambridge, Massachusetts.[4] "On reflection, we erred too much on the side of caution at Asilomar, quailing before unquantified (indeed, unquantifiable) concerns about unknown and unforeseeable perils", complained almost three decades later James Watson, the co-discoverer of the DNA structure and outspoken proponent of rDNA technology. Calling the contemporary controversy surrounding genetic modification a "Luddite paranoia", Watson predicted that following the "needless and costly delay" experienced by scientists in the past, the onset of the new millennium promised to resume the "pursuit of science's highest moral obligation: to apply what is known for the greatest possible benefit of humankind".[5]

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[3] Dorothy Nelkin, *Selling Science. How the Press Covers Science and Technology*, New York: W. H. Freeman, 1995: 35.

[4] The meeting is an example of successful science policy development through public involvement, see Craig Waddell, "The Role of Pathos in the Decision-Making Process: A Study in the Rhetoric of Science Policy" *Quarterly Journal of Speech* 76.4 (1990): 381-400; Sheldon Krimsky, "A Citizen Court in the Recombinant DNA Debate" *Bulletin of the Atomic Scientists* (Oct 1978): 37-43.

[5] James D. Watson and Andrew Berry, *DNA: The Secret of Life*, New York: Albert A. Knopf, 2003: 163.

The American public had been exposed to periodical increases in the frequency of news coverage of agricultural biotechnology since the 1970s. The media coverage of the topic often coincided with product breakthroughs such as the commercialization of the first GM fruit approved by the Food and Drug Administration; the Flavr Savr tomato. Created by Calgene, a small biotechnology company in Davis, California, the Flavr Savr contained an anti-ripening gene that extended the tomato's shelf life. Following a three-year period of testing, the FDA approved Flavr Savr tomato as safe for human consumption. The tomato appeared on supermarket shelves in 1994 and instantly fell victim to a heated public controversy which, when combined with other factors, eventually drove the tomato out of the market within a year. In her classic survey of the press coverage of science and technology in the United States, Dorothy Nelkin suggested that as criticism of biotechnology gained exposure, "skepticism became fashionable" and journalists began to describe the Flavr Savr in terms of "frankenfood" and "killer tomato", framing the public reactions to the product as "tomato war" or "tomatogate".[6] "The idea of injecting mouse genes into food, the spectacle of chefs boycotting the tomato, the concern about 'safe soup', attracted reporters who covered this product as an example of the risks that were bound to emerge from biotechnology", argued Nelkin. A journalist described such a spectacle which occurred in 2002 at a grocery market in Toronto:

> "Nothing on this day seems unusual until, suddenly, about 50 protesters march toward the grocery store, chanting, 'Hey hey, ho ho, leave our DNA alone.' . . . Another [woman] is far more creative: she is dressed from top to bottom as a gigantic, plump, red tomato, complete with a large stem and leaf jutting from her head and, bursting out from her vegetable belly, a fish head with eyes, fins, and gills".[7]

In their promotional materials and street performances, the opponents of genetic engineering frequently associated the Flavr Savr tomato with a different GM fruit created by the same

[6] Nelkin, *Selling Science*, 59.
[7] Jennie Addario, "Horror Show" *Ryerson Review of Journalism* (16 Mar 2002). Accessed 10 Apr 2014, http://www.rrj.ca/m3484/.

biotechnology company; a tomato containing genes of the Arctic flounder. In his examination of the myths and risks associated with GMOs, the geneticist Alan McHughen argued that Calgene's "fish-tomato" had been appropriated by such activists and the media as a tool for diverting the public attention from legitimate safety concerns consequent to the introduction of GM products into markets and environments toward the shocking artificiality of GM foods.[8]

Despite the optimistic framing of genetic engineering by the agricultural biotechnology industry, the recent decades witnessed the emergence of various social movements protesting against GM food crops.[9] An early study on the topic argued that public attitudes toward GMOs were "defined by the processes associated with genetic engineering rather than the products of these processes", where the critical dividing point was the relation of biotechnology to the conventional agricultural practices.[10] The opponents of agricultural biotechnology tend to emphasize the discontinuity between genetic modification and traditional agriculture, foregrounding the potential risks involved in the cultivation and consumption of GM plants, such as the evolution of pest resistant insects, unrestricted gene flow, allergenicity, or horizontal gene transfer. To rhetorically enforce their argumentation, the social movements present agricultural biotechnologies as unnatural and immoral, often emphasizing that the transfer of genes between different species could never occur spontaneously. In a 2001 interview, the vigorous opponent of GM crops Jeremy Rifkin juxtaposed "classical breeding" with recombinant DNA technologies by postulating the existence of

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8 Alan McHughen, *Pandora's Picnic Basket: The Potential and Hazards of Genetically Modified Foods*, Oxford: Oxford University Press, 2000: 16. See also Sheila Jasanoff, *Designs on Nature: Science and Democracy in Europe and the United States*, Princeton, NJ: Princeton University Press, 2005, 134-5.

9 For scholarship on social movements in the GMO debate in the United States and Europe, see Renata Motta, *Social Mobilization, Global Capitalism and Struggles Over Food: A Comparative Study of Social Movements*, London: Routledge, 2016; Christopher Ansell, Rahsaan Maxwell, and Daniela Sicurelli, "Protesting Food: NGOS and Political Mobilization in Europe," in *What's the Beef? The Contested Governance of European Food Safety*, Christopher Ansell and David Vogel (eds.), Cambridge, MA: The Massachusetts Institute of Technology Press, 2006; Rachel Schurman, "Fighting 'Frankenfoods': Industry Opportunity Structures and the Efficacy of the Anti-Biotech Movement in Western Europe" *Social Problems* 51.2 (2004): 243-68; Ann Elizbeth Reisner, "Social Movement Organizations' Reactions to Genetic Engineering in Agriculture" *American Behavioral Scientist* 44.8 (2001): 1389-1404.

10 Lynn J. Frewer, Chaya Howard, and Richard Shepherd, "Public Concerns in the United Kingdom about General and Specific Applications of Genetic Engineering: Risk, Benefit, and Ethics" *Science, Technology, and Human Values* 22.1 (1997): 98-124; 117.

such a boundary. "[T]hese new technologies", argued Rifkin, "allow scientists to bypass biological boundaries altogether", enabling them to "take a gene from any species – plant, animal, or human – and place it into the genetic code of your food crop or other genetically modified organism".[11]

While this type of activism successfully mobilized the public opinion against genetically modified foods in Europe, the same could not be said about consumers in the United States. Studies which have examined the public opinion on genetic engineering among the Americans offered various explanations, suggesting lack of sufficient information about the problem, disengagement, or radical split over the issue.[12] To explain the difference in public attitudes, scholars frequently refer to the general decrease in consumer trust in experts and confidence in food supply safety resulting from food scares which occurred in Europe during the second half of the 1990s, in particular, the Bovine Spongiform Encephalopathy (BSE) in beef. These events were not to any degree related to genetic engineering, however, the resultant atmosphere prompted the media to mirror these attitudes as reflected in the discourses of genetic modification articulated by social movements. And thus, it were the British journalists who coined phrases such as "Mutant Crops" and "Frankenstein Foods", or "Frankenfoods".[13] Even if the American consumers appeared and still appear engaged in the GMO problem to a lesser extent than the Europeans, the cultivation of genetically modified plants in the United States is surrounded with heated controversy which has recently found expression in a variety of formats.[14]

## I. *Public Attitudes Toward Agricultural Biotechnologies – A Survey of Scholarship*

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[11] John Palfreman, "Interviews. Jeremy Rifkin" *Harvest of Fear*, PBS, 2001, http://www.pbs.org/wgbh/harvest/interviews/, Accessed: August 2016.

[12] See Melissa Vecchione, Charles Feldman, and Shahla Wunderlich, "Consumer Knowledge and Attitudes About Genetically Modified Food Products and Labeling Policy" *International Journal of Food Sciences and Nutrition* 66.3 (2015): 329-35; Dominique Brossard and Matthew C. Nisbet, "Deference to Scientific Authority Among a Low Information Public: Understanding U.S. Opinion on Agricultural Technology" *International Journal of Public Opinion Research* 19.1 (2007): 24-52; William K. Hallman et al., *Public Perceptions of Genetically Modified Foods: A National Study of American Knowledge and Opinion*, New Brunswick, NJ: Food Policy Institute, 2003.

[13] For early examples, see "Frankenstein Food" *The Daily Telegraph* (12 Feb 1999): 1-2; "We Can't Control Mutant Crops" *The Express* (18 Feb 1999): 1.

[14] For examples of popular books on the topic, see Sheldon Krimsky and Jeremy Gruber (eds.), *The GMO Deception: What You Need to Know about the Food, Corporations, and Government Agencies Putting Our Families and Our*

The social significance of public debates about the introduction of genetically modified food crops into markets, ecosystems, and human bodies has during the last two decades prompted the growth of a body of literature which examined the public perceptions of biotechnology applications within the methodological boundaries of different fields.[15] Recent scholarship on the topic has granted much attention to the regulatory history of genetically modified organisms, with numerous comparative studies offering perspectives on the United States and European countries.[16] Scholars have also examined cultural perceptions of genetic engineering in popular culture formats such as general-interest magazines, television, cinema, comic books, or science fiction.[17] Members of the scientific community and science writers produced numerous works intended to inform the lay audiences about the applications of agricultural biotechnologies, frequently elaborating on the controversy and its impact on the development and regulation of GM foods on national markets.[18]

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*Environment at Risk*, New York: Skyhorse Publishing, 2014; F. William Engdahl, *Seeds of Destruction: The Hidden Agenda of Genetic Manipulation*, Montreal: Global Research, 2007; Jeffrey M. Smith, *Genetic Roulette: The Docuemnted Risks of Genetically Engineered Foods*, Portland, ME: Yes! Books, 2007; ibid, *Seeds of Deception: Exposing Industry and Government Lies About the Safety of the Genetically Engineered Foods You're Eating*, Portland, ME: Yes! Books, 2003; Daniel Charles, *Lords of the Harvest: Biotech, Big Money, and the Future of Food*, Cambridge, MA: Perseus Publishing, 2001. For documentary films, see *GMO OMG* (2013); *Seeds of Freedom* (2012); *David Versus Monsanto* (2009); *Food, Inc.* (2008); *The Future of Food* (2005).

[15] For a systematic review of the available literature on the reception of the agricultural biotechnology, see Lynn J. Frewer at al., "Public Perceptions of Agri-Food Applications of Genetic Modification – A Systematic Review and Meta-Analysis" *Trends in Food Science and Technology* 30.2 (2013): 142-52. See also Nidhi Gupta, Arnout R. H. Fischer, Lynn J. Frewer, "Socio-Psychological Determinants of Public Acceptance of Technologies: A Review" *Public Understanding of Science* 21.7 (2012): 782-95; Montserrat Costa-Font, José M. Gil, W. Bruce Traill, "Consumer Acceptance, Valuation of and Attitudes Towards Genetically Modified Food: Review and Implications for Food Policy" *Food Policy* 33.1 (2008): 99-111.

[16] Kelly A. Clancy, *The Politics of Genetically Modified Organisms in the United States and Europe*, Basingstoke: Palgrave Macmillan, 2016; Hannes R. Stephan, *Cultural Politics and the Transatlantic Divide over GMOs*, New York: Palgrave Macmillan, 2015; Luc Bodiguel and Michael Cardwell, *The Regulation of Genetically Modified Organisms: Comparative Approaches*, Oxford: Oxford University Press, 2010; Sheila Jasanoff, *Designs on Nature*.

[17] See Deborah L. Steinberg, *Genes and the Bioimaginary: Science, Spectacle, and Culture*, Burlington, VT: Ashgate, 2015; Jeffrey J. Kripal, *Mutants and Mystics: Science Fiction, Superhero Comics, and the Paranormal*, Chicago: University of Chicago Press, 2011; Jackie Stacey, *The Cinematic Life of the Gene*, Durham, NC: Duke University Press, 2010; Celeste M. Condit, *The Meanings of the Gene: Public Debates About Human Heredity*, Madison, WI: The University of Wisconsin Press, 1999; José Van Dijck, *Imagenation: Popular Images of Genetics*, Houndmills: Macmillan, 1998; Dorothy Nelkin and M. Susan Lindee, *The DNA Mystique: The Gene as a Cultural Icon*, New York: W. H. Freeman, 1995.

[18] For examples of popular works about agricultural biotechnology, see McKay Jenkins, *Food Fight: GMOs and the Future of the American Diet*, New York: Avery, 2017; Marion Nestle, *Food Politics: How the Food Industry Influences Nutrition and Health*, Berkeley: University of California Press, 2013 (revised and expanded tenth anniversary edition); Nina Fedoroff and Nancy Marie Brown, *Mendel in the Kitchen: A Scientist's View of Genetically Modified Foods*, Washington, DC: Joseph Henry Press, 2004; Peter Pringle, *Food, Inc: Mendel to Monsanto–the Promises and Perils of Biotech Harvest*, New York: Simon and Schuster, 2003; Alan McHughen, *Pandora's Picnic Basket: The Potential and Hazards of Genetically Modified Foods*, Oxford: Oxford University Press, 2000; Jon Turney, *Frankenstein's Footsteps: Science, Genetics, and Popular Culture*, New Haven: Yale

Public perceptions of genetic engineering are a frequent object of study among the sociologists of science, in particular, scholars who work within the public understanding of science (PUS) current.[19] A survey of studies published during the last two decades indicates the presence of both qualitative and quantitative approaches to investigating public attitudes toward the products and processes of genetic engineering.[20] Sociologists interested in the public opinion about GMOs often turn to the mass media, regarding these as a source of information about the degree of public interest in biotechnology, as well as of the prevailing social opinions regarding its applications. These scholars have thus explored the frequency, as well as the language of news features and reports about genetic engineering in the daily press.[21] Among studies referring to the audiences

University Press, 2000.

19 For examples of scholarship, see Andrew J. Knight, "Perceptions, Knowledge, and Ethical Concerns with GM Foods and the GM Process" *Public Understanding of Science* 18.2 (2008): 177-88; Wei Qin and J. Lynne Brown, "Public Reactions to Information About Genetically Engineered Foods: Effects of Information Formats and Male/Female Differences" *Public Understanding of Science* 16.4 (2007): 471-88; Martin W. Bauer, "Controversial Medical and Agri-Food Biotechnology: A Cultivation Analysis" *Public Understanding of Science* 11.2 (2002): 93-111; George Gaskell and Martin W. Bauer, *Genomics and Society. Legal, Ethical and Social Dimensions*, London: Earthscan, 2006; Martin W. Bauer and George Gaskell (eds.), *Biotechnology: the Making of a Global Controversy*, Cambridge: Cambridge University Press, 2002; Aidan Davison, Ian Barns, and Renato Schibeci, "Problematic Publics: A Critical Review of Surveys of Public Attitudes to Biotechnology" *Science, Technology, and Human Values* 22.3 (1997): 317-348; Nelkin and Lindee, *The DNA Mystique*; Sheldon Krimsky, *Biotechnics and Society: The Rise of Industrial Genetics*, New York: Praeger, 1991; ibid, *Genetic Alchemy: The Social History of the Recombinant DNA Controversy*, Cambridge, MA: MIT Press, 1982.

20 For examples of qualitative studies, see Monica Pivetti, "Natural and Unnatural: Activists' Representations of Animal Biotechnology" *New Genetics and Society* 26.2 (2007): 137-57; Wei Qin and J. Lynne Brown, "Consumer Opinions About Genetically Engineered Salmon and Information Effect on Opinions – A Qualitative Approach" *Science Communication* 28.2 (2006): 243-272. For examples of quantitative studies, see Ellen Townsend and Scott Campbell, "Psychological Determinants of Willingness to Taste and Purchase Genetically Modified Food" *Risk Analysis* 24.5 (2004): 1385-1393.

21 For scholarship, see Leonie A. Marks, Nicholas Kalaitzandonakes, Leonie A. Marks, and Ludmila Zakharova, "Mass Media Framing of Biotechnology News" *Public Understanding of Science* 16.2 (2007): 183-203; special issue on "Public Opinion on Biotechnology", *International Journal of Public Opinion Research* 17.1 (2005); Toby A. Ten Eyck, "The Media and Public Opinion on Genetics and Biotechnology: Mirrors, Windows, or Walls" *Public Understanding of Science* 14.3 (2005): 305-16; Claire McInerney, Nora Bird, and Mary Nucci, "The Flow of Scientific Knowledge From Lab to the Lay Public: The Case of Genetically Modified Food" *Science Communication* 26.1 (2004): 44-74; Miltos Liakopoulos, "Pandora's Box or Panacea? Using Metaphors to Create the Public Representations of Biology" *Public Understanding of Science* 11.1 (2002): 5-32; Matthew C. Nisbet and Bruce V. Lewenstein, "Biotechnology and the American Media: The Policy Process and the Elite Press, 1970 to 1999" *Science Communication* 23.4 (2002): 359-391; Susanna H. Priest and Allen W. Gillespie, "Seeds of Discontent: Expert Opinion, Mass Media, and the Public Image of Agricultural Biotechnology" *Science and Engineering Ethics* 6 (2001): 529-539; Susanna H. Priest, A *Grain of Truth: The Media, the Public, and Biotechnology*, Lanham, MD: Rowman & Littlefield, 2001; James Shanahan, Dietram Scheufele, and Eunjung Lee, "The Poll-Trends: Attitudes About Agricultural Biotechnology and Genetically Modified Organisms" *Public Opinion Quarterly* 65 (2001): 267-281.

located in the United Kingdom and the United States, an increasing number of works can be noted concerning Australia, as well as European, Asian, African, and South American countries.[22]

While some studies examine social perceptions of particular applications and present their insights on the basis of case studies, most scholarship focuses on the perceptions of food or plant biotechnology in general.[23] The literature examines the public perceptions of risk, often emphasizing the problematic of public trust in the available information about genetically modified organisms, and entities involved in developing and publishing this information. A different focus of research in the area concentrates around the public reception of the biotechnology industry and regulatory bodies, with a particular interest in issues related to consumer protection. Dorothy Nelkin indicated that "the reporting in the area suggests that biotechnological risk is in many ways a surrogate issue, linked to deeper ethical and religious issues, concerns about economic inequities, and public mistrust".[24] A significant chunk of the scholarship is therefore devoted to consumers' ethical concerns about genetically modified foods, in particular, about the prevailing attitudes which locate GMOs as immoral, or unnatural.[25]

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[22] See Lan Lü and Haidan Chen, "Chinese Public's Risk Perceptions of Genetically Modified Food: From the 1990s to 2015" *Public Understanding of Science* 21.1 (2016): 110-28; Massimiano Bucchi and Federico Neresini, *Cellule e cittadini. Biotecnologie nello spazio pubblico*, Milano: Sironi Editore, 2006; Jan Gutteling, Lucien Hanssen, Neil van der Veer, and Erwin Seydel, "Trust in Governance and the Acceptance of Genetically Modified Food in the Netherlands" *Public Understanding of Science* 15.1 (2006): 103-12; Paula Castro and Isabel Gomes, "Genetically Modified Organisms in the Portuguese Press: Thematisation and Anchoring" *Journal for the Theory of Social Behavior* 35.1 (2005): 1-18; Heather Dietrich and Renato Schibeci, "Beyond Public Perceptions of Gene Technology: Community Participation in Public Policy in Australia" *Public Understanding of Science* 12.4 (2003): 381-401; Kristine M. Grimsrud, Jill J. McCluskey, Maria L. Loureiro, and Thomas I. Wahl, "Consumer Attitudes to Genetically Modified Food in Norway" *Journal of Agricultural Economics* 55.1 (2004): 75-90; Jill J. McCluskey, Kristine M. Grimsrud, Hiromi Ouchi, and Thomas I. Wahl, "Consumer Response to Genetically Modified Food Products in Japan" *Agricultural and Resource Economics Review* 32.2 (2003): 222-31.

[23] For such case studies, see Carolina Gonzalez, Nancy Johnson, and Matin Qaim, "Consumer Acceptance of Second-Generation GM Foods: The Case of Biofortified Cassava in the North-East of Brazil" *Journal of Agricultural Economics* 60.3 (2009): 604-624; Wei Qin and J.Lynne Brown, "Consumer Opinions about Genetically Engineered Salmon and Information Effect on Opinions – a Qualitative Approach" *Science Communication* 28.2 (2006): 243-272.

[24] Nelkin, *Selling Science*, 60.

[25] For examples of different issues explored in the scholarship, see Joan Costa-Font and Elias Mossialos, "Are Perceptions of 'Risks' and 'Benefits' of Genetically Modified Food (In)dependent?" *Food Quality and Preference* 18.2 (2007): 173-82; ibid, "The Public as a Limit to Technology Transfer: The Influence of Knowledge and Beliefs in Attitudes Towards Biotechnology in the UK" *Journal of Technology Transfer* 31.6 (2006): 629-45; Assya Pascalev, "You Are What You Eat: Genetically Modified Foods, Integrity, and Society" *Journal of Agricultural and Environmental Ethics* 16.6 (2003): 583-94; Karsten K. Jensen and Peter Sandøe, "Food Safety and Ethics: The Interplay Between Science and Values" *Journal of Agricultural and Environmental Ethics* 15.3 (2002): 245-53.

The public controversy surrounding GMOs in the United States has recently moved into the problematic of information access, in particular to the regulations regarding the labeling of products containing GM plants. However, the problem of unnaturalness can still be noted in public statements of the vociferous opponents of GM foods, as well as among average consumers. Reports of such perceptions of unnaturalness appear throughout the scholarship mentioned above, where they are commonly linked to negative social responses.[26] One study based on fieldwork conducted between 1998 and 2000 in the United Kingdom located "the unacceptability and unnaturalness of genetic modification" as a recurring issue in the respondents' reception of the prompt materials provided during the interviews.[27] In her study, Alison Shaw reported that respondents in possession of detailed knowledge of the science of genetic engineering, as well as people who felt they lacked such knowledge, opposed the movement of genes across the species barrier. She reported "an intuitive unease" these individuals experienced at the suggestion of gene transfer between species, described by the participants as going "against the grain", "interfering with nature", or "'crossing of a line' that should not be crossed". A study conducted by Monica Pivetti among the Italian animal rights groups revealed a similar type of discourse as participants regarded the genetic modification of animals in the following terms: "it's against nature, if something is made in a certain way, then I think it's reasonable to respect it".[28] Shaw and Pivetti's insights relate to the recent perspectives on the problem from the field of psychology where scholars examined the emotional background of the social perceptions of genetic engineering, citing the feeling of disgust as the motivating factor in the intuitive reasoning behind the public support for legal restrictions on GM food.[29]

[26] Lynn J. Frewer at al. identified the topic as one of the prevalent themes in the literature, see "Public Perceptions of Agri-Food Applications of Genetic Modification".

[27] Alison Shaw, "'It Just Goes Against the Grain.' Public Understanding of Genetically Modified (GM) Food in the UK" *Public Understanding of Science* 11.3 (2002): 273-91.

[28] Pivetti, "Natural and Unnatural", 149.

[29] See Sydney E. Scott, Yoel Inbar, and Paul Rozin, "Evidence for Absolute Moral Opposition to Genetically Modified Food in the United States" *Perspectives on Psychological Science* 11.3 (2016): 315-24; Stefaan Blancke, Fran Van Breusegem, Geert de Jaeger, Johan Braeckman, and Marc Van Montagu, "Fatal Attraction: The Intuitive Appeal of GMO Opposition" *Trends in Plant Science* 20.7 (2015): 414-8; Ellen Townsend, David D. Clarke, and Betsy Travis, "Effects of Context and Feelings on Perceptions of Genetically Modified Food" *Risk Analysis* 24.5 (2004): 1369-84. For the so-called "yuck factor", see Nik Brown, "Xenotransplantation: Normalizing Disgust" *Science as Culture* 8.2 (1999): 327-55.

In her study of the sample of British consumers, Shaw suggested that what had prompted respondents to frame genetic modification as unnatural was the idea of a "scientific intervention to move genetic material across species". "[D]espite seeing the scientific value of genetic modification", she argued, "the majority rejected GM foods as 'unnatural'", frequently describing scientists as "playing God".[30] Within these discourses, Shaw noted the presence of a romanticized image of nature as fundamentally good, with human intervention into the natural order valued negatively. It is noteworthy that similar themes had appeared in public statements made by the opponents of genetic modification during the late 1990s. For instance, in 1999 Prince Charles, an outspoken opponent of GMOs, published an influential essay where he illustrated the sacrilegious character of genetic engineering in the following words: "Mixing genetic material from species that cannot breed naturally, takes us into areas that should be left to God. We should not be meddling with the building blocks of life in this way".[31] He reiterated this point on other occasions, installing in the public sphere a view of the natural environment as ordered and immutable, and species as natural kinds.[32]

It is then by no means unexpected that the problem of unnaturalness can be found at the core of scholarship exploring social perceptions of biotechnology. And yet relatively few scholars have provided explanations accounting for the ubiquity and endurance of such opinions on genetic engineering. Examining the reception of transgenic and cisgenic animals, Wolfgang Wagner and Nicole Kronberger argued that the process of collective coping with biotechnology involved a discourse of moral concern about human interference in natural processes.[33] In a more recent study,

[30] Shaw, "'It Just Goes Against the Grain'", 280.

[31] Charles Mountbatten-Windsor, "Prince Charles Speaks Out Against GM Food" BBC News (9 Apr 1999). Accessed April 2014, http://news.bbc.co.uk/2/hi/special_report/1999/02/99/food_under_the_microscope/285408.stm.

[32] For instance, see "Seeds of Disaster: HRH the Prince of Wales, Who Farms Organically, Says the Genetic Modification of Crops Is Taking Mankind into Realms That Belong to God, and God Alone" *Daily Telegraph* (Jun 8 1998): 16; "Prince Charles's Ten Questions on GM Food" *The Daily Mail* (1 Jun 1999). For Prince Charles's engagement in the GMO debate, see Jasanoff, *Designs on Nature*, 124-7.

[33] Wolfgang Wagner and Nicole Kronberger, "Discours et appropriation symbolique de la biotechnologie" (Discourse and symbolic coping with biotechnology, French) in *Les Formes de la pensée sociale* Catherine Garnier and Michel-Louis Rouquette (eds.), Paris: Presse Universitaires de France, 2002. See also Wolfgang Wagner, Nicole Kronberger, and Franz Seifert, "Collective Symbolic Coping with New Technology: Knowledge, Images and Public Discourse" *British Journal of Social Psychology* 41 (2002): 323-43.

they identified the reason for rejecting GMOs on this ground as a "threat to the symbolic order"; a stable system founded on the assumption that living organisms can be classified into meaningful categories, or natural kinds.[34] The scholars postulated that an "essentialist theory of hybrids" stood behind such conceptualizations of nature where the environment is imagined as a collection of categories unalterable by human intervention, and existing independently of human behavior.[35] Mixing the genes of plant or animal species, or other essentialized categories, would result in the creation of a non-entity, perceived as not belonging to any accepted category and subsequently rejected by perceivers with an essentialist mindset.

The problem of unnaturalness in GMOs appeared in anthropological studies as well. Stephen Crook noted that biotechnology is culturally risky because it problematizes the boundary between the natural and artificial which serves as the fundamental ordering principle in Western cultures.[36] In his analysis of the discursive formations which emerged around GM foods in the United States, the anthropologist Hugh Gusterson described the discourse of anti-GM activists to be "full of metaphors and images of mutation and contamination".[37] Gusterson also indicated that the anti-GM literature presents agricultural biotechnology products as potential genetic pollutants that imply a "confusion of categories", as represented in the examples of promotional materials of activists: "For the first time, humans are able to manipulate the very fabric of life, shuffling the genetic deck that controls every aspect of every living organism in ways that nature never intended", or "Genetic

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[34] Nicole Kronberger, Wolfgang Wagner, and Motohiko Nagata, "How Natural Is 'More Natural'? The Role of Method, Type of Transfer, and Familiarity for Public Perceptions of Cisgenic and Transgenic Modification" *Science Communication* 36.1 (2014): 106-130. See also George Gaskell, Wolfgang Wagner, and Nicole Kronberger, "Nature in Disorder: The Troubled Public of Biotechnology," in *Biotechnology 1996–2000: The Years of Controversy*, George Gaskell and Martin W. Bauer (eds.), London: Science Museum, 2001.

[35] Wolfgang Wagner, Nicole Kronberger, Motohiko Nagata, Ragini Sen, Peter Holz, and Fátima Flores Palacios, "Essentialist Theory of 'Hybrids': From Animal Kinds to Ethic Categories and Races" *Asian Journal of Social Psychology* 13.4 (2010): 232-46; Phil Macnaghten, "Animals in their Nature: A Case Study on Public Attitudes to Animals, Genetic Modification and 'Nature'" *Sociology 38*.3 (2004): 533-51. For literature on essentialism, see Susan A. Gelman, T*he Essential Child: Origins of Essentialism in Everyday Thought*, New York: Oxford University Press, 2003.

[36] Stephen Crook, "Biotechnology, Risk, and Sociocultural (Dis)order," in *Altered Genes: Reconstructing Nature*, Richard Hindmarsh, Geoffrey Lawrence, and Janet Norton (eds.), St. Leonards, NSW: Allen and Unwin, 1998.

[37] Hugh Gusterson, "Decoding the Debate on Frankenfood", in *Making Threats: Biofears and Environmental Anxieties*, Betsy Hartmann, Banu Subramaniam, and Charles Zerner (eds.), Lanham, MD: Rowman and Littlefield, 2005: 109-33.

engineering breaks down natural barriers between humans, animals, and plants".[38] In this sense, Gusterson argued, anti-GM activists may be regarded as "reactionary defenders of an established order that is threatened by the unlicensed border crossings of migrant genes" which problematize the essentialist categories of natural kinds.[39]

## II. *Toward the History of the Unnatural*

In their study of the gene in the American popular culture, Dorothy Nelkin and M. Susan Lindee suggested that one of the factors accounting for the rise of ethical and moral fears regarding genetic modification had been the vigorous public promotion of essentialist interpretations of genes and genomes, depicting the DNA as a sacred blueprint to all life on Earth.[40] Even if the very first GM products had been commercialized during the last decade of the twentieth century, the American society had already confronted the scientific modification of hereditary traits at the century's onset. Often represented as the pivotal point in the development of genetic technologies, the molecular biologists and rDNA technologies of the 1970s were in fact, as Helen Curry has recently argued, "late arrivals to a lively world of research into options for manipulating genes or chromosomes".[41] Indeed, the expression "Frankenfood" which encapsulated the risk, artificiality, and immorality of genetic modification may have emerged in the British press during the 1990s, however, the particular association of Frankenstein's monster with genetic modification dates back to the press representations of Hermann Muller's *Drosophila* mutations in the late 1920s. Examined in one of the following chapters, the Frankenstein trope is tightly woven into the history of public engagement with genetic modification; a history which remains to be written. When asked about the public engagement with the idea of evolutionary control in the United States, historians of science

[38] Qtd. in Gusterson, "Decoding the Debate", 115.
[39] Ibid, 121.
[40] Nelkin and Lindee, *The DNA Mystique*, xix-xx.
[41] Helen A. Curry, *Evolution Made to Order. Plant Breeding and Technological Innovation in Twentieth-Century America*, Chicago: University of Chicago Press, 2016: 10.

would likely suggest the vast literature elaborating on the rise of the American eugenic movement.[42] Even if this scholarship justly illustrates the degree to which visions of controlling human heredity enveloped the American society during the first half of the century, it only recounts a part of the story.

The other part is located among the American lay audiences which interacted with experimental technologies developed by scientists who sought to alter the genomes of plants and animals long before the emergence of rDNA. Historians of science have offered a number of accounts documenting such attempts at changing the hereditary properties of living organisms in agricultural and industrial contexts.[43] Helen Curry's recent examination of the American plant breeders' interest in technologies for creating new plant varieties on demand demonstrates the existence of such historical dimension. Weaving her account around the scientific and industrial uses of radioactive and chemical agents, Curry offered significant, even if limited, glimpses into the public engagement with the early pursuits in the area. In a recent account of the biological applications of the sensational element of radium, Luis Campos referred to the enthusiastic media coverage of such early attempts at genetic engineering of plants.[44] Other historical accounts of plant breeding hint on the public perceptions of genetic modification as well, in particular on the widespread moral opposition toward hybridization techniques, suggesting a lively circulation of knowledge about experimental breeding of plants and animals.[45] However, these works mention

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[42] For the history of the American eugenic movement, see Alexandra M. Stern, *Eugenic Nation. Faults and Frontiers of Better Breeding in Modern America*, Berkeley: University of California Press, 2005; Wendy Kline, *Building a Better Race: Gender, Sexuality, and Eugenics from the Turn of the Century to the Baby Boom*, Berkeley: University of California Press, 2001; Diane B. Paul, *Controlling Human Heredity: 1865 To the Present*, Atlantic Highlands, NJ: Humanities Press, 1995. For a classic study on the topic, see Daniel J. Kevles, *In the Name of Eugenics: Genetics and the Uses of Human Heredity*, New York: Knopf, 1985.

[43] See Hannah Landecker, *Culturing Life. How Cells Became Technologies*, Cambridge, MA: Harvard University Press, 2010; Susan R. Schrepfer and Philip Scranton (eds.), *Industrializing Organisms: Introducing Evolutionary History*, New York: Routledge, 2004; Robert Bud, *The Uses of Life: A History of Biotechnology*, Cambridge: Cambridge University Press, 1993; Philip J. Pauly, *Controlling Life. Jacques Loeb and the Engineering Ideal in Biology*, New York: Oxford University Press, 1987.

[44] Luis Campos, *Radium and the Secret of Life*, Chicago: University of Chicago Press, 2015.

[45] For examples, see Noel Kingsbury, *Hybrid. The History and Science of Plant Breeding*, Chicago: University of Chicago Press, 2009; Michael Leapman, *The Ingenious Mr. Fairchild: The Forgotten Father of the Flower Garden*, New York: St. Martin's Press, 2001; Conway Zirkle, *The Beginnings of Plant Hybridization*, Philadelphia: University of Pennsylvania Press, 1935.

public reactions to scientific breeding only in passing, using the archival material such as newspapers or periodicals to frame arguments which ultimately focus on developments located at the intersection of science and agricultural or industrial interests, not among the lay audiences. One notable historical study exploring the interactions of the Victorian society with unclassifiable organisms is Harriet Ritvo's *The Platypus and the Mermaid*.[46] Ritvo reconstructed the Victorian taxonomic practices and experiences of audiences which engaged with these biological oddities, demonstrating a link between animal hybrids and monsters; the anomalous organisms which invited alternative modes of understanding the natural world, and inspired the discourse of unnaturalness which – as I have indicated above – is the central problematic of genetic modification.

The vast scholarship on the public perceptions of genetic engineering focuses almost exclusively on the reception of rDNA technologies, ignoring the rich history of interactions between the American society and organisms with genomes modified by botanists, plant physiologists, and geneticists prior to the emergence of laboratory methods for genetic recombination. On the pages of this dissertation, I argue that tracing the history of public discourses which revolved around the concept of biological mutation – in the form of species transmutation, the mutation theory, or genetic mutation – allows access to a discursive space where such early interactions took place. Historians of biology have paid a moderate amount of attention to the concept of genetic mutation, usually elaborating on it in general surveys of the history of the evolutionary thought or the discipline of genetics.[47] The problem of mutation has been examined in scholarship on the

[46] Harriet Ritvo, *The Platypus and the Mermaid: And Other Figments of the Classifying Imagination*, Cambridge, MA: Harverd University Press 1998.

[47] Jan Sapp, *Genesis: The Evolution of Biology*, Oxford: Oxford University Press, 2003; Stephen Jay Gould, *The Structure of Evolutionary Theory*, Cambridge, MA: Harvard University Press, 2002; Peter J. Bowler, *The Mendelian Revolution: The Emergence of Hereditarian Concepts in Modern Science and Society*, Baltimore: Johns Hopkins University Press, 1998; Ernst Mayr, *The Growth of Biological Thought. Diversity, Evolution and Inheritance*. Cambridge, MA: Belknap Press of Harvard University Press, 1982; Peter J. Bowler, *The Eclipse of Darwinism: Anti-Darwinian Evolution Theories in the Decades Around 1900*, Baltimore: Johns Hopkins University Press, 1992; Peter J. Bowler, *Evolution. The History of an Idea*, Berkeley: University of California Press, 1989; Ernst Mayr, *The Growth of Biological Thought. Diversity, Evolution and Inheritance*. Cambridge, MA: Belknap Press of Harvard University Press, 1982.

mutagenic effects of exposure to radiation, especially in the context of the Atomic Age.[48] Historical accounts of the concept have also appeared in specialized dictionaries.[49] The single work dedicated in its entirety to genetic mutation is a slim volume by Elof A. Carlson which offers only a brief foray into the history of the idea.[50] As I have delineated above, recent scholarship exploring the history of life sciences in agricultural and industrial contexts demonstrates that the concept of genetic mutation had been inexorably tied to the problem of its control. In the introduction to her study, Curry persuasively argued that "the aspirations for tools and methods that would generate mutations on demand accompanied the very invention of mutation as a concept describing biological change".[51]

Examining three historical episodes which prompted the American society to confront the scientific concept of genetic mutation, in the present dissertation I explore the historical development of public attitudes to the possibility of altering the hereditary traits of living organisms. As the second chapter of the dissertation indicates, that possibility had been articulated already during the antebellum period, when editors of the reformist agricultural press called for hereditary experimentation and provided explicit instructions for inducing a "species transmutation". The etymology of the term "mutation" points to change, which in the biological context – at first appearing in the form of "transmutation" – implied the capacity for mutability of living organisms and challenged the traditional "like begets like" rule of heredity. During the antebellum period, the idea of a hereditary change, conceptualized as the transformation of one species into another, had already been linked to the problematic of unnaturalness. Tracing the

[48] Angela N. H. Creager, "Radiation, Cancer, and Mutation in the Atomic Age" *Historical Studies in the Natural Sciences* 45.1 (2015): 14-48; Angela N. H. Creager, *Life Atomic: A History of Radioisotopes in Science and Medicine*, Chicago: University of Chicago Press, 2013; M. Susan Lindee, *American Science and the Survivors at Hiroshima*, Chicago: University of Chicago Press, 1994.

[49] See Georg Toepfer, "Mutation" in *Historisches Wörterbuch der Biologie. Geschichte und Theorie der Biologischen Grundbegriffe*, Stuttgart und Weimar: Metzler, 2009: 655-68; Alain Pons, "Mutazione" in *Vocabulaire Européen des Philosophies – Dictionnaire des Intraduisibles*, Barbara Cassin (ed.), Paris: Seuil, 2004: 847-849.

[50] Elof A. Carlson, *Mutation: The History of an Idea from Darwin to Genomics*, Cold Spring Harbor: Cold Spring Harbor Press, 2011. See also Luis Campos and Alexander von Schwerin (eds.), "Making Mutations: Objects, Practices, Contexts", Preprint 393, Berlin: Max Planck Institute for the History of Science, 2010.

[51] Curry, *Evolution Made to Order*, 26.

history of public engagements with the idea of hereditary manipulation, each chapter of the dissertation thus unveils the historical and discursive circumstances which lead the American media to articulate the unnaturalness problem in the public sphere. Consequently, the dissertation aims to demonstrate that the discourses employed by the social movements campaigning against genetic engineering in the 1990s and the media – which are still reverberating among the American public – relied on essentialist assumptions about the natural environment which had circulated in the American press centuries prior to the emergence of rDNA technologies.

### III. *Structure of the Dissertation*

The dissertation is composed of four chapters, three of which are followed by appendices listing the archival material and primary sources appearing in each of these chapters.

The first chapter is dedicated to delineating the methodology employed in my study of public discourses revolving around the concept of genetic mutation in the United States. As a short introduction to the current challenges present in the scholarship exploring the history of science popularization, this chapter introduces a selection of arguments which have emerged in the scholarship engaged with the problem of popular science. Scholars in the field have expressed reservations about the so-called diffusionist model of disseminating scientific knowledge to the lay audiences, calling for more participatory frameworks describing the circulation of such knowledge in societies. I follow this discussion of the field's methodological shortcomings with a section where I situate my study in the geographical and chronological knowledge gaps in the field of the history of science popularization. The next section delineates in detail my approach toward studying public discourses of science in the American media. In particular, I describe each component of my methodology based on the notion that individuals and groups who communicate scientific knowledge in print media need to accommodate it in the public sphere by means of particular

strategies illustrated in the following chapters of the dissertation. I define the public sphere as a discursive space where variants of knowledge collide and compete with each other, traveling back and forth between expert and non-specialist media formats. In their coverage of experiments and reports involving the scientific concept of genetic mutation, editors and journalists adapted their representations to the requirements present in this space, for instance, the expectations shared by their audiences regarding the role played by science in the national economy. The process of adapting scientific knowledge to match these demands, articulated in a space occupied by rival forms of knowledge and narratives of nature, is thus the central focus of the dissertation.

In the second chapter, I trace the lively debate about species transmutation which unfolded in the Northeastern agricultural press between 1820 and 1859. As the chapter illustrates, the controversy offered agricultural reformers an opportunity for accommodating scientific knowledge about plant heredity and botanical classification systems among the agrarian community. The reformers aimed to resolve the debate by providing their readership with a forum for exchanging information in the form of personal observations and practical experiments conveyed in letters. The agricultural journals framed the problem of species transmutation in the American agricultural tradition of fact collecting and experimentation. The discipline of botany had been thus located in an experimental paradigm which contrasted "scientifically" obtained facts with the experience of practical farmers, and negotiated the authority of botany in particular, and science in general, for the study of nature in the context of the gradual professionalization of science. The chapter offers a number of reasons to account for the vision of nature communicated by American naturalists and agricultural reformers. Construed as stable and predictable, the representation of nature in the discourses of these groups drew on the argument for design characteristic for the American variant of natural theology. As a consequence, both groups represented processes such as species transmutation, or the generation of new species, as standing in violation of the universal laws that were imagined to govern the natural environment.

The third chapter demonstrates the continuity of the discourse which considered genetic modification or species mutability as unnatural in an analysis of media representations of the sensational theory of mutation proposed by the Dutch botanist Hugo de Vries. Upon his arrival on the American shore in the spring of 1904, de Vries had already become internationally famous and recognized in his home country as a foremost plant physiologist. De Vries intended to conquer with his theory the entire American nation, not only its scientific circles. Between 1904 and 1912, the botanist journeyed to the United States three times and with the help of the American scientific communities, he delivered numerous public lectures, published two books intended for lay audiences and contributed articles to professional, as well as general-interest periodicals. Local newspapers dutifully reported de Vries's American itinerary, noting meetings with famous scientists and participation in events which shaped the history of American life sciences, especially the discipline of genetics. De Vries's theory gained a number of dedicated followers in public and private institutions scattered across the United States. The American mutationists constructed their professional authority by promoting the mutation theory as a source of experimental methodology which could be productively applied to agriculture. Such a practical disposition resonated with American editors who eagerly represented the early experimental evolutionary biology through the lens of the Progressive and entrepreneurial view of pure scientific research. It were especially the Californian editors and audiences who imagined practical applications of de Vries's theory of mutation. Turn-of-the-century California offered a particularly conductive context for accommodating scientific knowledge about plant heredity in the public sphere. The intersection of genetic modification and agricultural profit had already been firmly established in the celebration of a renowned Californian horticulturist, Luther Burbank. The press conceptualized de Vries's mutation research as a theoretical counterpart to Burbank's practical achievements, suggesting that the theory promised a similar economic value even if no profitable mutations had ever materialized. De Vries capitalized on this relation by aligning *Oenothera* research and other experimental

evolutionary theories with the productive techniques of plant hybridization. Californian editors, who represented the growing entanglement of scientific knowledge and farming, emphasized the artificiality of products generated through scientific breeding, referring to them as “nature fakes” and scientists involved in breeding experiments as “nature fakers”. This example of an early discourse of genetic modification reflected the degree to which scientific breeding had been incompatible with other authoritative narratives of nature, in particular with John Muir's influential interpretation of the Californian wilderness.

The fourth chapter examines the coverage of Hermann Muller's sensational fruit fly experiments offered in prestigious publications with nationwide circulation such as the *New York Times*, in the 1920s and 1930s. Editors of such formats hired science writers to deliver quality coverage of science and technology news. Science journalists and editors thus participated in the creation of a national ideology of science, shaping science news in accordance with the views about the role of science in social progress which had circulated in their discursive domain. Erroneously presenting Muller as the first scientist to had ever altered a genome with x-ray radiation, science journalists chose not to foreground the practical applications of Muller's insight to agriculture, as had been the case with de Vries's mutation theory. Reflecting on the rapid technological advancement of the period, these writers shared a viewpoint postulating that human societies were not prepared to tackle the challenges of the modern world. Such perceived deficits in the human condition combined with other factors prompted these professionals to interpret Muller's experiments through the lens of the potential for controlling and improving humanity's evolution. Science writers endorsed the fantasy of evolutionary control in a context dominated by the religious-scientific discourse of science, championed by the charismatic popularizer Robert Millikan. The discourse was exemplified in the popular interpretation of Millikan's cosmic rays as a phenomenon demonstrating the continual evolution of the natural creation. Science journalists frequently joined their reports on Muller's x-ray experiments and Millikan's work on cosmic rays.

While the mutagenic properties ascribed to cosmic rays were valued positively as revealing the intrinsic order of nature, Muller's x-ray experiments interfered with nature by producing variations which did not fit into what had been depicted as the "natural design". Consequently, science writers developed a particular language for describing genetic mutation, aligning the concept with physical deformation and foregrounding the artificiality of organisms generated in laboratories.

In the final section of the present dissertation, I discuss the main points that the three historical episodes examined in the thesis have suggested regarding its central questions: 1) the existence of public engagement with hereditary modification among the American audiences prior to the development of rDNA technologies, 2) the presence of the public perception of "unnaturalness" associated with the modification of hereditary traits of living organisms, and 3) the reasons accounting for the articulation of the "unnaturalness" problem in the public sphere by the American print media. The dissertation shows that public attitudes toward manipulating genomes of living organisms had developed prior to the emergence of the rDNA technologies in the 1970s. As each chapter indicates, the American print media which represented the concept of biological mutation – in the form of species transmutation, the theory of mutation, and the genetic mutation – would also hint on its "unnaturalness". Examining the processes of accommodating scientific knowledge in the public sphere by the American editors and journalists, the dissertation illustrates how these representations of the concept transformed under the pressure of authoritative narratives of nature such as the American natural theology, the early American environmentalism, or the scientific-religious discourse of nature. Based on essentialist assumptions about the natural environment which had circulated among the American audiences, these narratives shaped – and continue to shape – the public engagement with products and processes of hereditary modification.

## Chapter 1

## Accommodating Scientific Knowledge in the Public Sphere: Toward a Methodology for Historicizing Science Popularization

### 1.1 *Introduction*

More than two decades ago, in a now-classic paper Roger Cooter and Stephen Pumfrey deplored the marginalization of "the low drama and the high art of science's diffusion and modes of popular production and reproduction" by historians of science.[52] A few years prior, Steven Shapin openly remarked that scholars "have scarcely any understanding of the range of beliefs entertained by lay members of our society, how these beliefs may relate to those maintained by scientists and what purposes may be fulfilled by lay thinking about nature".[53] He further argued that historians of science should "at least recognize the historical submergence of lay beliefs about nature as a problem and as a legitimate topic of historical inquiry". During the recent years, the call for a stronger focus on the history of popular science as part the history of "science proper" brought about a profusion of historical investigations into science popularization.[54]

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[52] Roger Cooter and Stephen Pumfrey, "Separate Spheres and Public Places: Reflections on the History of Science Popularization and Science in Popular Culture" *History of Science* 32 (1994): 237-67.

[53] Steven Shapin, "Science and the Public," in *Companion to the History of Modern Science*, Richard C. Olby et al. (eds.), London: Routledge, 1990: 990-1007; 994.

[54] For scholarship in the history of science popularization in the Anglophone world, see James A. Secord, *Visions of Science: Books and Readers at the Dawn of the Victorian Age*, Chicago: The University of Chicago Press, 2014; Peter J. Bowler, *Science for All. The Popularization of Science in Early Twentieth-Century Britain*. Chicago: The University of Chicago Press, 2009; Bert Hansen, *Picturing Medical Progress from Pasteur to Polio: A History of Mass Media Images and Popular Attitudes in America*, New Brunswick, NJ: Rutgers University Press, 2009; Constance A. Clark, *God–or Gorilla. Images of Evolution in the Jazz Age*, Baltimore: The Johns Hopkins University Press, 2008 Marcel C. LaFollette, Science on the Air: Popularizers and Personalities on Radio and Early Television, Chicago: The University of Chicago Press, 2008; Bernard Lightman, *Victorian Popularizers of Science*, Chicago: The University of Chicago Press, 2007; James A. Secord, *Victorian Sensation: The Extraordinary Publication, Reception and Secret Authorship of Vestiges of the Natural History of Creation*, Chicago: The University of Chicago Press, 2000; Iwan Rhys Morus, *Frankenstein's Children: Electricity, Exhibition and Experiment in Early Nineteenth-Century London*, Princeton: Princeton University Press, 1998; Alison Winter, *Mesmerized: Powers of Mind in Victorian Britain*, Chicago: The University of Chicago Press, 1998; Marcel C. LaFollette, *Making Science Our Own. Public Images of Science 1910-1950*, Chicago: The University of Chicago Press, 1990; John C. Burnham, *How Superstition Won and Science Lost. Popularizing Science and Health in the United States*, New Brunswick:

It has become common for scholars to reject the stereotypical understanding of popularization which divided the scientific community (the producer of esoteric knowledge) from the lay public (the receiver of this knowledge).[55] Stephen Hilgartner called this arrangement a "two-stage model" where scientists generated knowledge which would then be disseminated by mediators, or "popularizers", in a watered-down version to a passive public.[56] This model for understanding science popularization, also called the diffusionist model, or the dominant view, is founded on the assumption that scientific communities and lay audiences are divided by a gap which had increased with the professionalization of science during the nineteenth and twentieth centuries. The diffusionist model thus represents the production of scientific knowledge as isolated from the surrounding cultural, social, and economic realities.

### 1.2 *History of Science Popularization – Current State of the Field*

The expression "popularization" emerged in the English language during the nineteenth century as a concept accompanying the gradual professionalization, specialization, and formalization of scientific discourses. In the standard narrative of science popularization sketched above, these factors are interpreted as contributing to the widening of the gap between scientific elites and lay masses. According to Bernardette Bensaud-Vincent, the increasing detachment of science from the public peaked during the emergence of quantum mechanics and relativity theory, a

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Rutgers University Press, 1987; Roger Cooter, *The Cultural Meaning of Popular Science: Phrenology and the Organization of Consent in Nineteenth-Century Britain*, Cambridge: Cambridge University Press, 1984.

[55] For the historiography of popular science, see Bruce V. Lewenstein, "Popularization," in *The Oxford Companion to the History of Modern Science*, John Heilbron (ed.), Oxford: Oxford University Press, 2003: 667-8; Bernadette Bensaude-Vincent, "A Genealogy of the Increasing Gap between Science and the Public" *Public Understanding of Science* 10.1 (2001): 99-113, Bruce V. Lewenstein (ed.), *When Science Meets the Public*, Washington, D.C.: American Association for the Advancement of Science, 1992. See also "Communicating Science: National Approaches in Twentieth-Century Europe" (special issue) *Science in Context* 26.3 (2013): 393-549; "Historicizing 'Popular Science'" (focus section) *Isis* 100.2 (2009): 310-68, in particular Jonathan Topham, "Introduction" *Isis* 100.2 (2009): 310-18; "Science Popularization" (special issue) *History of Science* 32 (1994): 237-360, in particular Anne Secord's examination of the meaning of "popular science": Anne Secord, "Science in the Pub: Artisan Botanists in Early Nineteenth-Century Lancashire" *History of Science* 32 (1994): 269-315.

[56] Stephen Hilgartner, "The Dominant View of Popularization: Conceptual Problems, Political Uses" *Social Studies of Science* 20.3 (1990): 519-39.

moment which called for mediation between the two social groups, meant to increase the public support for scientific research.[57] The task of mediators was the translation of the complex scientific language into a discourse understandable to the general audiences. Such model of communicating scientific knowledge pictured the public as a passive, undifferentiated gathering of mere consumers of science and technology, located at the receiving end of scientific advances. Popularization had thus been defined as a one-way diffusion of esoteric knowledge to audiences whose defining trait was the deficit of such knowledge. Beginning in Victorian Britain, science popularization – understood as mediation geared toward increasing the public understanding of science and scientific practices – had been expected to generate positive attitudes toward the newly-emergent profession of a scientist. In reality, as Bensaud-Vincent argued, "popularization has contributed to isolating scientists from the rest of the world and to turning science into a sacred, all-powerful deity—thus increasing, rather than decreasing, the alleged gap".[58]

The fragmentation of what Robert M. Young described as the common cultural context shared by Victorian science with other forms of knowledge had shaped the meaning of "popularization" in the Anglophone world.[59] Since the term "science popularization" emerged in particular circumstances and had been articulated for specific, locally-relevant purposes, it should not be expected to accommodate the entire breadth of possible interactions between scientific knowledge and the society at large. The limitations posed by the notion of popularization as delineated above are striking in particular when compared with alternative concepts developed in different national settings such as the French term "vulgarisation", or the German expression

[57] Bensaude-Vincent, "A Genealogy of the Increasing Gap Between Science and the Public".

[58] Bernardette Bensaud-Vincent, "A Historical Perspective on Science and Its 'Others'" *Isis* 100.2 (2009): 359-68; 363. See also Ulrike Felt, "Why Should the Public 'Understand' Science? A Historical Perspective on Aspects on the Public Understanding of Science", in *Between Understanding and Trust: The Public, Science and Technology*, Meinolf Dierkes and Claudia von Grothe (eds.), Amsterdam: Harwood Academic Publishing, 2000: 7-38.

[59] Robert M. Young, "Malthus and the Evolutionists: The Common Context of Biological and Social Theory" *Past and Present* 43.1 (1969): 109-45. For criticism of the Young's concept, see Jonathan Topham, "Beyond the 'Common Context': The Production and Reading of the Bridgewater Treatises" *Isis* 89.2 (1998): 233-62.

"Wissenschaftspopularisierung".[60] Following the canonical narrative of the increasing gap between the scientific communities and the lay public which had rendered scientific discourses inaccessible to non-specialist audiences (or even across scientific disciplines), "popular science" came to be recognized by scientists, as well as historians of science, as inconsequential to the process of knowledge production.

Steven Shapin and Simon Shaffer's pioneering *Leviathan and the Air-Pump* challenged the view of scientific activity as pure by offering an account of science in public which paved the way toward the development of the public culture of science current. Abandoning the vision of scientific production as an isolated activity, historians of science have since investigated the circulation of scientific ideas in societies and constructed science as a social phenomenon, delivering accounts which challenged the assumed discontinuity of cultural competencies dividing the scientific community from the general public.[61] "Popular science" or "science popularization" became recognized as insufficient to provide accurate accounts of the transfer of knowledge between scientific communities and other social groups. The expression "science popularization" may in fact easily function as an umbrella term, obscuring the richness and variety of the modalities of information circulation. Moreover, the term implies a simplified distinction between expert and non-expert knowledge. At its emergence in Victorian Britain, "science popularization" had been used by various social groups as a means of "bringing science to the people", emphasizing the

[60] For historiographies of science popularization in France, see Bernardette Bensaud-Vincent, "Splendeur et décadence de la vulgarisation scientifique" *Questions de communication* 17 (2010): 19-32; Daniel Raichvarg and Jean Jacques, *Savants et ignorants: Une histoire de la vulgarisation des sciences*, Paris: Seuil, 1991; Bruno Béguet (ed.), *La science pour tous: Sur la vulgarisation scientifique en France de 1850 á 1914*, Paris: Bibliotheque du Conservatoire National des Arts et Métiers, 1990. For Germany, see Carsten Kretschmann (ed.), *Wissenspopularisierung: Konzepte der Wissensverbreitung im Wandel*, Berlin: Akademie, 2003; Andreas W. Daum, *Wissenschaftspopularisierung im 19. Jahrhundert: Bürgerliche Kultur, naturwissenschaftliche Bildung und die deutsche Öffentlichkeit, 1848–1914*, Munich: Oldenbourg, 2002.

[61] For examples of works in the public culture of science, see Steven Shapin and Simon Shaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*, Princeton: Princeton University Press, 1985; Jan Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1769-1820*, Cambridge: Cambridge University Press, 1999; ibid, *Making Natural Knowledge: Constructivism and the History of Science*, Chicago: The University of Chicago Press, 1998; Larry Stewart, *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660-1750*, Cambridge: Cambridge University Press, 1992; David Gooding, *Experiment and the Making of Meaning: Human Agency in Scientific Observation and Experiment*, Dordrecht: Kluwer, 1990.

cultural hegemony of the scientific community over the production of knowledge. The concept of science popularization had thus legitimated the authority of scientists and constructed their expertise as reliable and verifiable.

Bearing in mind the etymology of "science popularization" and the canonical narrative of the widening gap between science and the public, historians as already mentioned have frequently problematized the diffusionist model of science communication. However, even if the historiography of science popularization openly and frequently dismissed this framework, the call for alternative, more participatory models of science communication has so far been left partly unanswered.[62] The model of expository science, based on a "sort of continuum of methods and practices utilized both within research and far beyond, for purposes of conveying science-based information", has not reverberated among historians attempting to capture the complexities of scientific knowledge in society.[63] In a survey of the recent attempts at historicizing popular science, Andreas W. Daum suggested that few historians had in fact subscribed to the frequently criticized model, pointing out that its abundant critique had failed to offer any productive alternatives.[64] Daum proposed a formula for de-essentializing and historicizing the notion of "popular science" based on its understanding as a set of "variations of a much larger phenomenon–that is, as transformations of public knowledge across time, space, and cultures".[65]

Recent comments on the state of the field often point to the loaded character of the terms "popularization" or "popular", calling for conceptual frameworks that would revoke the differentiation between science proper and popular science.[66] In particular, James Secord suggested

[62] Stephen Hilgartner, "The Dominant View"; Richard Whitley, "Knowledge Producers and Knowledge Acquirers: Popularisation as a Relation between Scientific Fields and Their Production," in *Expository Science: Forms and Functions of Popularisation*, Terry Shinn and Richard Whitley (eds.), Dordrecht: Reidel, 1985: 3-28. For a perspective from Science, Technology and Society studies, see Michel Callon, "The Role of Lay People in the Production and Dissemination of Scientific Knowledge" *Science, Technology, and Society* 4.1 (1999): 81-94.

[63] See Terry Shinn and Richard Whitley (eds.), *Expository Science: Forms and Functions of Popularisation*, Dordrecht: Reidel, 1985: viii.

[64] Andreas W. Daum, "Varieties of Popular Science and the Transformations of Public Knowledge: Some Historical Reflections" *Isis* 100.2 (2009): 319-332.

[65] Daum, "Varieties of Popular Science", 320.

[66] Jonathan Topham, "Rethinking the History of Science Popularization/Popular Science," in *Popularizing Science and Technology in the European Periphery, 1800–2000*, Faidra Papanelopoulou, Augustí Nieto Galan, Enrique

replacing "popular science" or "science popularization" with a broader, communication-oriented notion of "knowledge in transit". Instead of examining scientific knowledge in local or general contexts, Secord argued, historians of science should shift their focus to communication and "think about knowledge-making itself as a form of communicative action".[67] "Rather than saying that an idea was 'popular', a 'best seller', or a 'sensation', we need to analyze audiences and readerships closely and carefully, with the same awareness of cultural nuance we might bring to an account of life in the laboratory".[68] Otherwise, historians risk reproducing the diffusionist model of communication.

However, "popular science" remains relevant as an actors' category.[69] In the present dissertation, the expression "science popularization" refers to the mindsets and actions of individuals and groups among the American scientific or intellectual elites which had articulated an intention of diffusing scientific knowledge. The following chapters illustrate how individually-defined and case-specific motivations guided these figures and communities in producing accounts of science intended for the lay audiences. The second chapter documents the efforts of the Northeastern community of social reformers in installing scientific knowledge relevant to agriculture in the public sphere. The editors of agricultural journals presented the knowledge about botanical classification and plant heredity to their readers convinced that such popularizations would serve to eradicate what they deemed superstitions – for instance, the belief in species transmutation – and spread the improvement mindset among nineteenth-century Northeastern farming communities. The third chapter refers to Daniel T. MacDougal's efforts in establishing the public authority of experimental botany for addressing the problem of heredity among professional

Perdiguero (eds.), Aldershot: Ashgate, 2009: 1-20; James A. Secord, "Knowledge in Transit" *Isis* 95.4 (2004): 654-72.

67 Secord, "Knowledge in Transit", 661.

68 Ibid, 662.

69 In the introduction to the special issue of *Science in Context* on national science popularization, Arne Schirrmacher pointed out how "popularization" as an actor's category disappeared around 1900 in various European countries, see Arne Schirrmacher, "Introduction: Communicating Science: National Approaches in Twentieth-Century Europe" *Science in Context* 26.3 (2013): 393-404.

breeders, farmers, and horticulturists. When assessed in this context, MacDougal's intention of appealing to these non-specialist audiences renders his editorship of Hugo de Vries's Berkeley summer school lectures an example of science popularization as an actors' category. As the chapter illustrates, MacDougal's lively interest in building the public image for his discipline, combined with de Vries's investment in disseminating his sensational findings to broader audiences, situated the volume as one of the attempts at constructing the very category of "the public" for science during the first decade of the twentieth century. The last chapter of the dissertation presents the emergence of a brand new profession, science journalism. A most prominent example of this emerging new group of professional writers – and a significant presence in the chapter – was Waldemar Kaempffert, the science editor at the *New York Times* who reportedly "described himself as vulgariser of science when anybody asked him what he did for a living".[70] Kaempffert had operated with a particular idea of science popularization and a public for science in mind, producing accounts of scientific news and editing reports written by staff journalists in a manner which articulated his views on the social significance of science and technology, to be discussed in the fourth chapter of the dissertation.

Tracing the discursive processes which contributed to the shaping of public knowledge about genetic mutation, the present dissertation offers a body of work which can be situated within the corpus of scholarship investigating the history of popular science and science popularization in the Anglophone world. Recent criticism recognizes this field as severely imbalanced and in favor of accounts of Victorian science popularizers and popularizations. Scholars such as James Secord, Andreas Daum, and Katherine Pandora have all pointed to the asymmetry between studies concerning Great Britain and the United States.[71] Pandora furthermore argued that the majority of historical investigations into American science considers the problem of popular science and non-

[70] "Kaempffert the 'Vulgariser'" *New Scientist* 4 (13 Dec 1956): 6-7.

[71] Daum, "Varieties of Popular Science"; Katherine Pandora, "Popular Science in National and Transnational Perspective: Suggestions from the American Context" *Isis* 100.2 (2009): 346-358; Secord, "Knowledge in Transit".

specialist audiences for scientific knowledge from the perspective of the scientific community itself. Consequently, the dissemination of knowledge within what she defines as the American vernacular remains underresearched.[72]

The geographical imbalance is especially evident in scholarship exploring the circulation of scientific knowledge during the nineteenth century. The dramatic increase of studies exploring the modalities of science popularization in Victorian Britain has not been matched by a similar wave of scholarship investigating science dissemination in the United States at the time of the Antebellum Republic, which is the central topic of the second chapter of the dissertation. This trend in the historiography of science popularization is especially evident in relation to print media such as the periodical press which are of particular interest to the present study.[73] The imbalance in the field is thus not only of geographical, but also temporal nature. While scholarship investigating the nineteenth century bloomed, historians offered relatively few accounts of science popularization during the twentieth century.[74] In the following chapters, I investigate the popular representations of scientific knowledge produced during the nineteenth and early twentieth century in the United States, with significant references to contemporary developments in Great Britain.

When examining public representations of science, historians frequently turn their attention to books or periodicals, ignoring the daily press as a rich source of primary historical material. Indeed, historians rarely study newspapers in their own right. They tend to use newspapers as

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[72] Pandora, "Popular Science", 347. For investigations into science in the American popular culture, see David Thurs, *Science Talk. Changing Notions of Science in American Popular Culture*, New Brunswick: Rutgers University Press, 2007; Dorothy Nelkin, *Selling Science. How the Press Covers Science and Technology*, New York: W. H. Freeman, 1987.

[73] For scholarship on British science periodicals, see James Mussell, *Science, Time, and Space in the Late Nineteenth-Century Periodical Press: Movable Types*, Aldershot: Ashgate, 2007; Jonathan R. Topham, "Publishing 'Popular Science' in Early Nineteenth-Century Britain," in *Science in the Marketplace: Nineteenth-Century Sites and Experiences*, Aileen Fyfe and Bernard Lightman (eds.), Chicago: The University of Chicago Press, 2007: 135-168; Geoffrey Cantor and Sally Shuttleworth (eds.), *Science Serialized: Representations of the Sciences in Nineteenth-Century Periodicals*, Cambridge, MA: MIT Press, 2004; Geoffrey Cantor et al. (eds.), *Science in the Nineteenth-Century Periodical: Reading the Magazine of Nature*, Cambridge: Cambridge University Press, 2004; Louise Henson et al. (eds), *Culture and Science in the Nineteenth-Century Media*, Aldershot: Ashgate, 2004; Ruth Barton, "Just Before Nature: The Purposes of Science and the Purposes of Popularization in Some English Popular Science Journals of the 1860s" *Annals of Science* 55.1 (1998): 1-33.

[74] See Bowler, *Science for All*, 1-4.

archival records which demonstrate broadly-construed ideological trends and social attitudes toward particular topics. Considered as ecosystems of knowledge, newspapers differ from the periodical press in the way in which they present and interpret information. While periodicals explore specific themes with homogeneous audiences in mind, the daily press offers a glimpse into less elaborate and more spontaneous accounts. Representations of science and technology in newspapers have recently become the domain of sociologists interested in the role of mass media in shaping the interactions between science and society.[75] Frequently relying on quantitative methods which codify and analyze vast numbers of digitized source materials, these scholars unravel the changing attitudes toward science expressed by societies over long periods of time. Two chapters of this dissertation offer a qualitative historical analysis of the representations of science produced in this rarely-explored format, by investigating the strategies employed by editors and journalists in writing and curating scientific news in newspapers.

The reconstruction in chapter two, three, and four, of three historical episodes when scientific knowledge about the manipulation of plant and animal heredity had become prominent in the American press illustrates different modalities of accommodating scientific knowledge in the public sphere. My primary interest in analyzing the circulation of science in print media formats is exposing the discursive mechanisms which governed the representations of scientific knowledge produced by and for different communities, ranging from scientists, science journalists, intellectual elites, to the educated middle classes. I therefore compare different discourses of science as they were articulated by the groups involved in presenting scientific knowledge to the public, situating my account in line with Katherine Pandora and Karen A. Rader's argument that "[s]cience as it

[75] For examples of such studies, see Vasilia Christidou, Kostas Dimopoulos and Vasilis Koulaidis, "Constructing Social Representations of Science and Technology: the Role of Metaphors in the Press and the Popular Scientific Magazines" *Public Understanding of Science*, 13 (2004): 347-362; Massimiano Bucchi and Renato G. Mazzolini, "Big Science, Little News: Science Coverage in the Italian Daily Press, 1964-1997" *Public Understanding of Science*, 12 (2003): 7-24; Martin W. Bauer and Ingrid Schoon, "Mapping Variety in Public Understanding of Science" *Public Understanding of Science*, 2 (1993): 141-155. An exception to this is Faidra Papanelopoulou and Peter C. Kjærgaard, "Making the Paper: Science and Technology in Spanish, Greek, and Danish Newspapers Around 1900" *Centaurus* 51 (2009): 89-96.

occurs within popular culture is not simply a more dilute, less sophisticated, error-plagued imitation of 'real' science", but "it, too, is 'real' science, in the encompassing sense that the 'scientific imagination' belongs not only to scientists and their realms of expertise but […] also to ordinary people and everyday circumstances".[76] As Steven Shapin pointed out, scientists employ the public language to communicate their findings, and this type of discourse "may involve metaphors and analogies whose resonances they cannot expect to hold in place and control".[77] The following chapters depict the transformation of such public language under the force of authoritative cultural narratives which dominated the discursive landscape when public expositions of knowledge about genetic mutation had intensified on the pages of American newspapers and periodicals from 1820 to 1945.

### 1.3 *Science in the Public Sphere*

As already discussed, "popular science" and "science popularization" are loaded terms which do not clarify processes such as the communication and exchange of scientific knowledge.[78] Does "popular science" refer exclusively to science in its popularized version, or does the category include a broader range of possible interpretations of science – for instance, the production of cross-disciplinary publications intended for scientific audiences? Is it fair to speak of "scientific" knowledge once it has been transformed by the media into a type of public commodity? In investigating the producers of and audiences for scientific knowledge, as well as the impact of its circulation upon the production of new knowledge, the present dissertation will adopt a "participatory" approach, focusing on the process of accommodating science in the public sphere.

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[76] Katherine Pandora and Karen A. Rader, "Science in the Everyday World. Why Perspectives from the History of Science Matter" *Isis* 99.2 (2008): 350-65; 351.

[77] Shapin, "Science and the Public", 997.

[78] For criticism of the concept of "popular culture", see John Storey (ed.), *Cultural Theory and Popular Culture: A Reader*, Harlow: Pearson, 2006; Dominic Strinati, *An Introduction to Theories of Popular Culture*, London: Routledge, 2004; Morag Shiach, *Discourse on Popular Culture: Class, Gender, and History in Cultural Analysis, 1730 to the Present*, Stanford: Stanford University Press, 1989.

What happens to scientific knowledge when it leaves the confines of the laboratory and enters the public sphere? My understanding of the "public sphere" departs somewhat from Jürgen Habermas's concept of *Öffentlichkeit* which had been previously employed by historians of science to discuss the various modalities of making scientific knowledge public.[79] Andreas Daum, in his already mentioned contribution to a focus section entitled "Historicizing 'Popular Science'", offered a productive definition of public knowledge as "a changing set of material, cultural, and intellectual practices and presentations—and the consumption thereof—aimed at creating and communicating knowledge as a commodity in public enterprises".[80] These practices, argued Daum, "are defined by mechanisms of inclusion and exclusion, generate market-like situations, and respond to and themselves articulate cultural, social, and political preferences". These are developed by individuals and social groups to "make meaningful statements about themselves and the natural and cultural worlds they find themselves in—all of which may change over time". Daum thus offers an alternative approach toward investigating the public sphere, urging historians to look "for the processes, actors, and ideas that have aimed at allowing parts of society to participate in knowledge (while excluding others)—without assuming that these processes led necessarily to the development of seemingly distinct public spheres, as opposed to seemingly 'private' ones".[81]

The present dissertation defines the public sphere as a discursive space occupied by different variants of knowledge which invariably collide and compete with each other. Steven Shapin had long ago situated scientific knowledge in "a field of contest" resulting from the constant negotiation of its authority among the public.[82] The three historical episodes examined in the following chapters demonstrate that knowledge which had originated among scientists or intellectual elites, did not

[79] Jürgen Habermas, *The Structural Transformation of the Public Sphere: An Inquiry Into the Category of the Bourgeois Society*, Cambridge: Polity, 1989 [1962]. For the concept of public sphere in the history of science, see Thomas Broman, "The Habermasian Public Sphere and 'Science *in* the Enlightenment'" *History of Science* 36.2 (1998): 123-49. See also Augustí Nieto-Galan, *Science in the Public Sphere: A History of Lay Knowledge and Expertise*, New York: Routledge, 2016.

[80] Daum,"Varieties of Popular Science", 331.

[81] Ibid, 329.

[82] Shapin, "Science and the Public", 995.

hold an unquestionable authority over other forms of knowledge by default. In fact, my examination of the media representations of scientific knowledge exposes its transformation under the pressure of rival forms of knowledge or narratives of nature. Set at the time when science crystallized as a profession in the United States, the first chapter illustrates how these alternative systems of knowledge had contributed to shaping the public expectations regarding scientific methodology, by articulating the views nineteenth-century communities of social reformers held about science. The second chapter pinpoints the clash of two competing narratives of nature as the point of origin for the particular language employed by the local Californian press to describe organisms whose hereditary traits had been modified by botanists or zoologists. The last chapter of the dissertation locates the provenance of the specific public understanding of genetic mutation as a process leading to an organism's deformation in the conflict between another set of two distinct narratives of nature.

The model I adopt combines an understanding of the public sphere as a space marked by discursive competition, with the expression "accommodation" to account for the circulation of scientific knowledge in different media and contexts. In choosing this concept to guide my analysis of science coverage in the American media, I follow the suggestions made by scholars such as James Secord or Jonathan Topham, in response to the so-called "communicative turn" in the historical investigation of science in public. I therefore draw on the rich array of scholarship devoted to the problem of science communication, which renders scientific knowledge part of the general communicative process; a dynamic which – as Topham pointed out – involves activities such as appropriation, resistance, or cultural contestation.[83] In their seminal essay, Cooter and Pumfrey already suggested that "'popularizations' are communicative processes", therefore "their histories must attend to the history of communicative production" and its inevitable technological discontinuities.[84] In this way, they further argue, popularization of science should not be treated as

[83] Topham, "Rethinking the History of Science Popularization", 19-20.
[84] Cooter and Pumfrey, "Separate Spheres", 239.

"a uniform or universal process".[85] Each of the following chapters illustrates the dissemination of scientific knowledge as dependent on a variety of social, cultural, and economic factors – including the differences between alternative types of print media, and the emergence of brand new formats such as the radio.

Bruce Lewenstein suggested that an examination of science in the mass media "must be an exploration of the complexity of interactions among all media", including technical media reserved for expert communities.[86] In their review of the public understanding of science field, Jane Gregory and Steven Miller aligned Lewenstein's web model with Niklas Luhmann's framework of communication networks which, as they argued, "might consider the boundaries of science not as fences between separate domains of cultural and intellectual activity, but as limits of open territories which may overlap with other domains, and which are themselves superposed on culture as a whole".[87] In this framework, science proper and popular science figure as parts of a single communication system, allowing "popularization to be considered not as something peripheral to scientific activity, or as deviant or pathological, but as an integral function of normal scientific life".

The following chapters explore the discursive practices employed by various individuals and groups – including scientific communities – for representing scientific knowledge in the American media. The arguments contained in each chapter are founded on a close reading of primary materials from diverse sources such as agricultural journals, local newspapers, or nationwide prestigious daily press. I situate the content of these formats within a web of expert and non-specialist media connected with each other in a broader discursive space. Referring to the exchanges and borrowings which occurred in this space, I illustrate their interconnection and describe the modalities in which scientific facts traveled between technical publications intended for scientific publics and media formats targeting other types of audiences.

[85] Ibid.

[86] Bruce V. Lewenstein, "From Fax to Facts: Communication in the Cold Fusion Saga" *Social Studies of Science* 25.3 (1995): 403-36; 427.

[87] Jane Gregory and Steve Miller, *Science in Public: Communication, Culture, and Credibility*, New York: Basic Books, 1998: 87-8.

## 1.4 *Accommodating Scientific Knowledge in the Public Sphere*

Based on the process I call the accommodation of science in the public sphere, my framework embraces the variability of different media formats and modes of popularization by relying on the concept of discourse, as I investigate the processes of interpretation and construction of meaning in the public representations of science. My use of "discourse" refers to a cluster of such linguistic practices, drawing on the tradition of analysis established within the so-called "linguistic turn" in the humanities.[88] Another term critical to my analysis of print media content is narrative. Constructed to fulfill specific purposes and refer to the tastes, preferences, and capabilities of particular audiences, narratives also played a critical role in shaping the public image of scientists and their disciplines. In an examination of the significance of texts in the social construction of biology, Greg Myers contrasted narratives of science with narratives of nature.[89] While narratives of science appear in professional publications and present a parallel series of simultaneous events which support a given claim, narratives of nature are constructed in science popularizations. The latter often focus on the subject of scientific investigation, for instance a plant or an animal, placing scientific activity in the background. These narratives are sequential and chronological. Most importantly, they emphasize the externality of nature to scientific practice.[90] As the following chapters demonstrate, setting such a clear-cut distinction between the narratives produced in different formats entails a demarcation between the expert narratives of science and lay narratives of nature, a distinction problematized by the numerous interpretations of scientific knowledge traveling back and forth between these two ends of the science communication spectrum.

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88 For the significance of the linguistic turn to history of science, see Jan Golinsky, "Language, Discourse and Science," in *Companion to the History of Modern Science*, Richard C. Olby et al. (eds.), London: Routledge, 1990: 110-23. See also G. Nigel Gilbert and Michael Mulkay, *Opening Pandora's Box. A Sociological Analysis of Scientists' Discourse*, Cambridge: Cambridge University Press, 1984.

89 Greg Myers, *Writing Biology: Texts in Social Construction of Scientific Knowledge*, Madison: Wisconsin University Press, 1990: 141-2.

90 For externality in scientific reports, see Trevor Pinch, "Towards an Analysis of Scientific Observation: The Externality and Evidential Significance of Observational Reports in Physics" *Social Studies of Science* (1985): 3-36.

My analysis opens with a close examination of the representations of biological mutation offered in the American print media. In particular, I employ the concept of "accommodation" to account for the activities of the media professionals in presenting scientific knowledge to their readerships. The process of adaptation or accommodation of scientific knowledge is in fact the central focus of the dissertation. I borrow the expression "accommodation" from the work of the rhetoric scholar Jeanne Fahnestock. When explaining the concept of accommodation, she suggested that scientific accommodations are not only geared at reporting facts for non-specialist audiences but are "overwhelmingly epideictic"; they are designed to display a particular rhetorical skill.[91] Furthermore, she argued, such accommodations "must usually be explicit in their claims about the value of the scientific discoveries they pass along" as "[t]hey cannot rely on the audience to recognize the significance of information". According to Fahnestock, the work of science journalists includes the element of "epideictic rhetoric" which requires "the adjustment of new information to the audiences' already held values and assumptions". As the following chapters illustrate, in their coverage of scientific concepts such as genetic mutation, editors and journalists adapted their representations to the preferences and expectations held by their diverse audiences. Thus, the interpretations of genetic mutation which appeared in the American press can be considered to implicitly hint on the interests, tastes, assumptions, and mindsets of publics located at the receiving end of the coverage.

The concept of "accommodation" aligns my methodology with the narratological notion of the implied reader which emerged within reader-response criticism. Coined in 1961, the term "implied reader" designates the recipient of a text as imagined by its author.[92] One interpretation of

[91] Jeanne Fahnestock, "Accommodating Science: The Rhetorical Life of Scientific Facts," in *The Literature of Science: Perspectives on Popular Scientific Writing*, Murdo W. McRae (ed.), Athens, GA: University of Georgia Pres, 1993: 17-36.

[92] The term was coined by Booth, see Wayne C. Booth, *The Rhetoric of Fiction*, Chicago: University of Chicago Press, 1983 [1961]. For an introduction to the concept, see Wolf Schmid, *Narratology. An Introduction*, Berlin: de Gruyter, 2010: 52-4. For scholarship on the implied reader, see Umberto Eco, *The Role of the Reader: Explorations in the Semiotics of Texts*, Bloomington: Indiana University Press, 1979; Wolfgang Iser, *The Act of Reading: A Theory of Aesthetic Response*, Baltimore: Johns Hopkins University Press, 1978 [1976]; Wolfgang Iser, *The Implied Reader: Patterns of Communication in Prose Fiction from Bunyan to Beckett*, Baltimore: Johns Hopkins University Press,

the implied reader proposes to treat it as a presumed addressee whose linguistic codes, aesthetic preferences, and ideological norms are replicated in the text with the intention to foster its understanding. Authors may, of course, be mistaken in their assumptions about the knowledge, abilities, or prevalent ideological positions of their readerships. An alternative interpretation of the implied reader relates it the concept to the ideal addressee, a receiver imagined to be capable of understanding a text from the interpretive standpoint of the author. The position of the ideal reader is predetermined by the text and the spectrum of interpretive stances it permits.

Both variations of the implied reader offer a productive domain for interpreting textual content in print media such as newspapers or periodicals. Following the assumption that editors and journalists addressed their textual representations to particular audiences, my analysis of science coverage in such media formats – conducted with the concept of the implied reader in mind – sheds light on the attitudes, preferences, and expectations these audiences had regarding American science and the American scientific community. Each of the following chapters documents the response of media professionals to scientific knowledge, as well as to the public expectations regarding this knowledge. In this sense, editors, journalists, and other contributors to these formats may be understood as mediators who at the same time act as the receivers of particular representations of science (in forms ranging from expert to non-specialist books, lectures, or reports), and the producers of such representations. The dissertation aims to illustrate how such a participatory model of science popularization may be encapsulated in the particular status these professionals held within the ecosystems of knowledge to which they belonged.

The concept of the implied reader indicates that the audiences of the media discussed in the dissertation played an active role in the production of the representations of scientific knowledge about heredity and later genetics. The application of the implied reader concept to textual content

1974 [1972].

produced in print media can be productively aligned with the sociology of expectations as well.[93] Since innovation in science and technology relies on the creation of capabilities and opportunities oriented toward the future, images, visions, and expectations are understood to shape fundamental changes in both technologies and scientific practice. Expectations held by audiences regarding the shape and role of science provide legitimation and authority, guide scientific activity, clarify roles and duties, warrant the production of scientific and technological artifacts, and attract public interest. Borup at al. suggest that expectations mediate across different social dimensions of technoscientific communities: "Expectations are foundational in the coordination of different actor communities and groups (horizontal co-ordination) and also mediate between different scales or levels of organization (micro, meso, and macro—vertical co-ordination). They also change over time in response and adaptation to new conditions or emergent problems (temporal coordination)".[94]

As the following chapters show, the expectations about science and technology shared by American lay audiences, media professionals, and scientific communities had a decisive impact on the representations of scientific knowledge in newspapers and magazines. The second chapter illustrates this by showing the activities of social reformers who in their coverage of scientific themes were guided by a particular expectation of agricultural improvement. They disseminated botanical knowledge about plant heredity and classification in the hope of bringing about the reality of agricultural progress they envisioned as appropriate for the Northeastern farmers. In the third chapter, I show how the arrival of Hugo de Vries's internationally-recognized theory of mutation prompted newspaper editors located in the San Francisco Bay Area to articulate specific expectations regarding the applications of scientific knowledge about plant and animal heredity. The chapter illustrates the similarities in these expectations and visions cultivated by scientists who

[93] For introduction to the sociology of expectation, see: Mads Borup et al, "The Sociology of Expectations in Science and Technology" *Technology Analysis & Strategic Management* 18.3/4 (2006): 285-98. For historical studies of expectation, see Roy Porter, "Medical Futures" *Interdisciplinary Science Reviews* 26.1 (2001): 35-42; Carolyn Marvin, *When Old Technologies Were New*, Oxford: Oxford University Press, 1990; Miriam Levin, *When the Eiffel Tower was New: French Visions of Progress at the Centennial of the Revolution*, Cambridge, MA: University of Massachusetts Press, 1989.

[94] Borup et al, "The Sociology of Expectations", 286.

promoted de Vries's theory, together with Mendelism, as factors significant to the improvement of American agriculture. The fourth chapter examines an altogether different set of expectations, regarding the shape of American national science, and the potential of science in general to control the process of evolution which surfaced in the coverage of Hermann Muller's fruit fly experiments.

## 1.5 *Conclusion*

The goal of this dissertation is not reconstructing what American audiences thought about the concept of genetic mutation or the prospect of modifying the hereditary traits of plants and animals. My objective is to combine different representations of the idea in search for a broader "popular mind" which allowed for the emergence of particular attitudes toward the problem of the genetic modification of organisms. The following chapters focus on discourses articulated by the American media professionals in combination with relevant texts produced by the members of the scientific community, intellectual elites, or lay audiences. In delineating such a discursive space, often marked by competition, I depict the transformation of the public language of science under the force of authoritative narratives of nature, which dominated the discursive landscape when the expositions of genetic mutation intensified on the pages of the American newspapers and periodicals. The dissertation thus explores the rhetorical strategies employed by different social groups in constructing various meanings of scientific knowledge to serve particular objectives. As we shall see, these goals ranged from commercial success among newspaper editors and establishment of disciplinary authority among scientists, to democratization of scientific knowledge among science journalists, or installation of the improvement ideology among nineteenth-century intellectual reformers.

The dissertation thus offers a perspective on science in public by presenting media accounts of scientific knowledge as derivatives of knowledge transfer processes which are based on

continuous feedback loops and exchanges between different parties involved in knowledge circulation. The various constellations of these individuals and groups, combined with their agendas embedded in broader cultural, social, and economic contexts, had a decisive effect on the shape of science in the American public sphere. By showing how different social groups participated in constructing the meaning of genetic mutation, I aim at blurring the demarcation between the production and consumption of science which has been problematized in the historiography of science popularization.

## Chapter 2

## Immutable Boundaries: Species Transmutation and Agricultural Press in Northeastern United States, 1820-1859

### 2.1 *Introduction*

"Although contrary to every known law of vegetable physiology, and without a single analogy in the whole range of organized existence, the transmutation of wheat into chess found believers and supporters among many of our respectable farmers". Such complaint had been shared by one of the many contributors to the *Cultivator*, a prime example of the flourishing agricultural press which circulated in the Northeastern United States before the Civil War.[95] During the first half of the nineteenth century, numerous farmers believed that environmental conditions could prompt wheat seeds to produce cheat or chess; a variety of weed belonging to the *Bromus* genus. The widespread belief in the transmutation of wheat into chess was based on testimonies shared by farmers who reported sowing what they believed to be clean wheat seeds only to find their crop infested with the pervasive weed. Agricultural periodicals provided a forum for exchanging hypotheses regarding the origin of chess. While transmutationists considered chess as degenerated wheat brought about by humidity or frost, those who opposed transmutation firmly believed that chess appeared as a result of farmers' carelessness in cleaning seed. Anti-transmutationists further argued that by leading farmers to believe that seed cleaning would not prove effective against the

[95] "Culture of Wheat" *Cultivator* v.9 1842: 163. For the history of the American agricultural press, see Albert Lowther Demaree, *The American Agricultural Press, 1819-1860*, New York: Columbia University Press, 1941. For other sources, see Sally McMurry, "Who Read the Agricultural Journals? Evidence from Chenango County, New York, 1839-1865" *Agricultural History* 63 (1989): 1-18; Nicolas Goddard, "The Development and Influence of Agricultural Periodicals and Newspapers, 1780-1880" *The Agricultural History Review* 31.2 (1983): 116-31; Richard Abbott, "The Agricultural Press Views the Yeoman: 1819-1859" *Agricultural History* 42 (1968): 35-44; George F. Lemmer, "Early Agricultural Editors and Their Farm Philosophies" *Agricultural History* 31.4 (1957): 3-22; Norman J. Lemmer, *Colman and Colman's Rural World: A Study in Agricultural Leadership*, Columbia: University of Missouri Press, 1953; Demaree, "The Farm Journals, Their Editors, and Their Public, 1830-1860" *Agricultural History* 15 (1941): 182-8. For a list of agricultural periodicals published during this period, see Stephen Conrad Stuntz, *List of the Agricultural Periodicals of the United States and Canada Published during the Century July, 1810, to July, 1910*, Washington, DC: U. S. Department of Agriculture, 1941.

inevitable transmutation of the grain, the doctrine prevented the implementation of learned farming practices. Along with the widespread belief in the impact of moon cycles on farming, the doctrine of species transmutation prevailed as a deeply-rooted superstition which, as contemporary reformers believed, inhibited agricultural improvement on the Eastern coast of the United States. To readers, contributors, and editors of agricultural periodicals – predominantly well-off agriculturists, educated landowners, or gentlemen farmers – the doctrine of transmutation remained a superstition which prevented Eastern farmers from joining the national momentum of progress.[96]

Inaugurated in 1820, the transmutation debate continued unabated for more than forty years, reaching peaks of exposition in the early 1830s and mid-1840s. Following a brief intensification of the controversy after the publication of Charles Darwin's *On the Origin of Species*, the transmutation debate gradually disappeared from the last two major Northeastern agricultural journals at the beginning of the 1860s.[97] Even if debated with a particular vigor during the antebellum period, the theory of species transmutation had not been a novelty to a nineteenth-century readership. "Almost any other grain has in former times been charged with this freak", remarked one contributor.[98] Long before David Thomas and Gideon Ramsdell exchanged their heated letters in the first significant transmutation controversy, historical sources had pointed to the origin of cereal crops in transmutation, contributing to the incorporation of ideas such as spontaneous generation or heterogony in the European agricultural tradition. Accounts of cereal crops converting into one another, described by the recognized English botanist Agnes Arber as "fabulous, but widely credited", can be found in the writings of Theophrastus, Pliny, St Thomas Aquinas, or in Virgil's *Georgics*.[99] Tracing the history of grains transmutation, Arber suggested that the problem arose due to a philological confusion over a Latin term which originally signified a fine

[96] For a classic study of the idea of progress in nineteenth-century American society, see Arthur A. Ekirch, *The Idea of Progress in America, 1815-60*, New York: Columbia University Press, 1944.

[97] The inference is based on the analysis of two Northeastern agricultural periodicals which survived till the 1860s, the *Country Gentleman* and the *American Agriculturist*.

[98] M. S. D., "'Popular Errors,' No. 3. – Chess" *Cultivator* v.7 1840: 163.

[99] Conway Zirkle, "Species Before Darwin" *Proceedings of the American Philosophical Society* 103.5 (1959): 636-44; 640.

variety of wheat, and had been mistaken to stand for rye. This seemingly slight translation error gave birth to the doctrine of transmutation which had spread through the European agricultural tradition and reached the shores of the United States, exploding on the pages of the antebellum agricultural periodicals.[100]

Contributors who participated in the transmutation debate pointed out the regrettably American character of the controversy. One reader lamented: "In these more enlightened times, and especially, in this *free country*, where belief is too often untrammelled, even by reason, we have found a shorter road to folly, by allowing the wheat to pass directly into cheat".[101] Arguing against transmutation at the height of the debate during the 1830s, the polymath David Thomas admitted to not having ever encountered the topic of transmutation in British literature. "It therefore appears that this supposed transmutation is an *Americanism*", he concluded.[102] The belief in the transmutation of wheat into chess had indeed been widespread throughout the nineteenth-century American rural society, to the extent that an American reviewer of Robert Chambers's anonymously published *Vestiges of the Natural History of Creation* positioned species transmutation as "a very common tendency of thought".[103] "No popular error has been more generally held in this country than that wheat will turn to chess. No other subject has, during the past fifty years, been more actively discussed in the agricultural press", wrote Arthur Crozier in his 1891 *Popular Errors About Plants*.[104] As late as 1898, the United States Department of Agriculture would publish volumes which included extensive argumentation against the transmutation of wheat into chess.[105] However, the belief in transmutation had by no means been a uniquely American phenomenon as it

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[100] Agnes Arber, *The Gramineae: A Study of Cereal, Bamboo, and Grass*, Cambridge: Cambridge University Press, 2010 [1934]: 15-6.

[101] "Is Wheat Convertible Into Cheat?" *Farmer's Cabinet* v.2 1838: 322-4 (emphasis original).

[102] David Thomas, "Chess" *Genesee Farmer* v.2 1832: 300-1.

[103] "Vestiges of Creation and Sequel" *Christian Examiner and Religious Miscellany* May 1846: 334. For the reception of Chambers's Vestiges, see James A. Secord, *Victorian Sensation: The Extraordinary Publication, Reception and Secret Authorship of Vestiges of the Natural History of Creation*, Chicago: University of Chicago Press, 2000.

[104] Arthur A. Crozier, *Popular Errors About Plants*, Ann Arbor, MI: The Register Publishing Company, 1891.

[105] Frank Lamson-Scribner, *Economic Grasses*, Washington, DC: The United States Department of Agriculture, Division of Agrostology, 1898: 24.

made a frequent appearance in the British agricultural press in relation to wheat, as well as other grains such as corn or rye.[106]

The transmutation debate occurred during the rise of public interest in broadly-construed agricultural improvement. Classic scholarship on the history of the American agriculture dates the flowering of this movement around 1820 and locates its expansion in the 1840s.[107] The gradual growth of urban populations combined with the emergence of novel transportation modes contributed to the shaping of a commercially-oriented agriculture in the Northeastern United States. Contrary to the long-standing tradition of self-sufficient family farming, this type of agriculture considered surplus production as its primary objective. The acceptance of a market-focused agriculture had been slow, and numerous American farmers stuck to the family farm tradition till as late as the 1850s.[108] Profitable participation in the market economy required farmers to search for and implement improvements intended to advance productivity. The reluctance towards agricultural improvement had been reflected in the common hostility toward new farming techniques, technologies, or – as the transmutation controversy illustrated – knowledge produced by intellectual elites, all grouped under the often derogatory term "book farming".[109]

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[106] For examples of references to species transmutation in England, see "Transmutation of Corn" *Gardener's Chronicle* v.4 1844: 573; "Nature and Art" *Gardener's Chronicle* v.4 1844: 829-30; "Transmutation of Corn" *Gardener's Chronicle* v.6 1846: 102; "Transmutation of Grain" *Gardener's Chronicle* v.9 1849: 411; "Transmutation of Species" *Gardener's Chronicle* v.10 1850: 358; "Transmutation of Wild Oats, and Hybridisation of the Swede" *Journal of Agriculture* v.7 1855-7: 600.

[107] Philip J. Pauly, *Fruits and Plains. The Horticultural Transformation of America*, Cambridge, MA: Harvard University Press, 2007; Sarah T. Phillips, "Antebellum Agricultural Reform, Republican Ideology, and Sectional Tension" *Agricultural History* 74.4 (2000): 799-822; Jeremy Atack and Fred Bateman, *To Their Own Soil: Agriculture in the Antebellum North*, Ames: Iowa State University Press, 1987; Margaret W. Rossiter, "The Organization of Agricultural Improvement in the United States, 1785-1865," in *The Pursuit of Knowledge in the Early American Republic*, Alexandra Oleson and Sanborn Brown (eds.), Baltimore: Johns Hopkins University Press, 1976; Clarence H. Danhof, *Change in Agriculture. The Northern United States, 1820-1870*, Cambridge, MA: Harvard University Press, 1969; Earl W. Hayter, *The Troubled Farmer 1850-1900: Rural Adjustment to Industrialism*, DeKalb: Northern Illinois University Press, 1968; Paul W. Gates, *The Farmer's Age: Agriculture, 1815-1860*, New York: Holt, Rinehart, and Winston, 1960; T. Swann Harding, *Two Blades of Grass: A History of Scientific Development in the U.S. Department of Agriculture*, Norman: University of Oklahoma Press, 1947.

[108] For resistance to market-focused agricutlure, see Thomas Summerhill, *Harvest of Dissent: Agrarianism in Nineteenth-Century New York*, Urbana: University of Illinois Press, 2005.

[109] A good example of this mindset are reactions to Justus Liebig's immensely popular *Chemistry and Its Application to Agriculture and Physiology*, see Margaret Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840–1880*, New Haven: Yale University Press, 1975; Demaree, *The American Agricultural Press*, 66-8.

However, strategies for improvement had been of interest to Eastern farmers during the first decades of the nineteenth century as they experienced increased market competition from the vast and fertile Midwestern farmlands. Combined with the progressing exhaustion of local soils, the westward agricultural expansion rendered Northeastern farmers particularly receptive to innovation and improvement. As Sarah Phillips noted in her study of the antebellum agricultural reform, "the full flowering of periodical literature coincided with the advent of western migration and the reappraisal of old-style farming methods".[110] Agricultural journals became the medium reformers chose for disseminating knowledge they believed would fuel the improvement of agricultural practices among Eastern farmers.

In a survey of contemporary American agriculture, a prominent agricultural writer Jesse Buel openly argued that "the more it is enlightened by science, the more abundant will be its products".[111] Numerous reformers shared Buel's conviction in the value of disseminating scientific knowledge as part of the national improvement project. In an editorial from an ambitious but short-lived journal, *The American Quarterly Journal of Agriculture and Science*, the renowned geologist Ebenezer Emmons and physician Alanson J. Prime stated the following:[112]

> "There is, probably, at the present moment, a greater sacrifice of time, labor and money, in the cultivation of soil, than in any other department of human industry. Of this, every intelligent observer is fully aware; and hence the imperious demand which has gone forth for the speedy application of an appropriate remedy […] concerning the nature of the remedy to be applied, there is, also, no dispute. All agree that it consists in the application of scientific knowledge to practical farming".[113]

The decades between 1785 and 1865 witnessed the emergence of sciences relevant to the practice of farming such as agricultural chemistry, botany, entomology, or geology. Chemistry received most

[110] Phillips, "Antebellum Agricultural Reform", 803.
[111] Jesse Buel, *The Farmer's Companion: or, Essays on the Principles and Practice of American Husbandry*, Boston: Marsh, Capen, Lyon, and Webb, 1842: 14.
[112] For biographical information, see Edward Dorr Griffin Prime, *Notes Genealogical, Biographical and Bibliographical, of the Prime Family*, Cambridge, MA: John Wilson and Son, University Press, 1888: 75-8.
[113] N. S. Davis, "Agricultural Science, Education, &c." *The American Quarterly Journal of Agriculture and Science* v.1 1845: 50-7.

public attention in this context, beginning with Humphrey Davy's 1813 *Elements of Agricultural Chemistry*, and blossoming with the publication of Justus Liebig's 1840 *Chemistry and Its Application to Agriculture and Physiology*.[114] As Margaret Rossiter noted in her seminal study of the American agricultural improvement, the demand for scientific research into agricultural matters exceeded the supply until as late as the 1870s.[115] The lack of systematic experimentation methods that would allow for accurate assessment of improvements generated a need for research which culminated in the establishment of state experiment stations. A significant figure in launching the agricultural scientific research was Henry L. Ellsworth, the first commissioner of the U.S. Patent Office, which during the 1840s became the primary governmental agency supporting agricultural improvement.[116] In a report reprinted in the *New Genesee Farmer*, Ellsworth positioned science as a critical factor to the growth of the American agriculture: "If the application of the sciences be yet further made to husbandry, what vast improvements may be anticipated!".[117]

In the context of the vivid interest in agricultural improvement, the topic of species transmutation allowed for the accommodation of scientific knowledge about plant heredity and botanical classification systems among the antebellum agrarian community. Presenting botanical knowledge as a remedy to the belief in species transmutation, reformers who curated the contents of the agricultural press aimed to resolve the controversy by offering their readership a forum for exchanging information acquired in observations and practical experiments. Encouraging their audiences to test wheat crops for transmutation and come forward with proofs, these editors located botanical knowledge in an experimental paradigm which had long been part of the American

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[114] For public engagement with chemistry during the Antebellum period, see Margaret Rossiter, *The Emergence of Agricultural Science*; ibid, "Benjamin Silliman and the Lowell Institute: The Popularization of Science in Nineteenth-Century America" *The New England Quarterly* 44.4 (1971): 602-26.

[115] Rossiter, "The Organization of Agricultural Improvement", 282.

[116] For this aspect of the U.S. Patent Office activities, see Philip J. Pauly, *Fruits and Plains*, Chapter 5.

[117] "Interesting Report of the Commissioner of Patents" *New Genesee Farmer* v.3 1842: 54. In his final report published by the Office in January 1845, Ellsworth lamented over the contingent state of American agricultural research, restating the point about the immense value of science to agriculture in a vision where "[g]uesswork and hereditary notions are yielding to analysis and the application of chemical principles" (*Annual Report of the Commissioner of Patents For the Year 1844*, January 28 1845: 6).

agricultural tradition. At the same time, the agricultural press contrasted "scientifically" obtained facts with the experience of practical farmers, negotiating the authority of botany and other sciences in the study of nature. The American naturalists, as well as agricultural reformers, represented nature as a stable, ordered, and predictable entity, drawing on the argument for design that had been part of the American tradition of natural theology. As a consequence of this association, both groups excluded species transmutation, generation, or hybridization, from the natural order, portraying these processes as standing in violation of the universal laws that were imagined to govern the natural environment.

### 2.2 *Popularizing Science in the Antebellum Republic*

During the nineteenth century, the American natural history underwent professionalization as solitary pioneers in the vein of Daniel Drake or Thomas Nuttal were gradually replaced with specialized professionals tied to academic institutions, for instance, Asa Gray or Louis Agassiz.[118] As scholarship tracing the development of the American science indicates, the notable lack of full-time scientists or institutional frameworks that would support them contributed to the deficient status of science in the early American Republic.[119] In a classic examination of American science

[118] For professionalization of natural history, see Philip J. Pauly, *Biologists and the Promise of American Life*, Princeton: Princeton University Press, 2000; Keith R. Benson, "From Museum Research to Laboratory Research: The Transformation of Natural History into Academic Biology" in *The American Development of Biology*, ed. Ronald Rainger, Keith R. Benson, and Jane Maienschein, Philadelphia: University of Pennsylvania Press, 1988; Arthur F. Hughes, *The American Biologist Through Four Centuries*, Springfield, IL: James C. Thomas, 1982. For scholarship on the early American naturalists, see Lee Alan Dugatkin, *Mr. Jefferson and the Giant Moose. Natural History in Early America*, Chicago: University of Chicago Press, 2009; John Moring, *Early American Naturalists: Exploring the American West, 1804-1900*, New York: Cooper Square Press, 2002; Gail Fishman, *Journeys through Paradise: Pioneering Naturalists in the Southeast*, Gainesville and Tallahassee: University Press of Florida, 2000; Howard Ensign Evans, *Pioneer Naturalists: The Discovery and Naming of North American Plants and Animals*, New York: Holt, 1993; Pamela Regis, *Describing Early America: Bartram, Jefferson, Crevecoeur, and the Rhetoric of Natural History*, Dekalb: Northern Illinois University Press, 1992.

[119] For scholarship on professionalization of science in nineteenth-century United States, see Paul Lucier, "The Professional and the Scientist in Nineteenth Century America" *Isis* 100.4 (2009): 699-732; Mark V. Barrow, "The Specimen Dealer: Entrepreneurial Natural History in America's Gilded Age" *Journal of the History of Biology* 33 (2000): 493-534; Willis Conner Sorensen, *Brethren of the Net. American Entomology, 1840-1880*, Tuscaloosa: The University of Alabama Press, 1995; Hugh R. Slotten, *Patronage, Practice, and the Culture of American Science. Alexander Dallas Bache and the U.S. Coast Survey*, Cambridge: Cambridge University Press, 1994; Robert V. Bruce, *The Launching of Modern American Science, 1846-76*, New York: Alfred A. Knopf, 1987; Mary Ann James, *Elites in Conflict: The Antebellum Clash over the Dudley Observatory*, New Brunswick and London: Rutgers

during the Jacksonian period, George Daniels noted how the culture of the era contributed to the emergence of professional science, even if "at the beginning of the century it was virtually impossible to arouse either public or private support for any scientific enterprise.[120]

Scholars who examined the history of science popularization in nineteenth-century United States suggested that the dismal state of American science matched a similar decline in the popular interest in science before 1815.[121] As the increasing professionalization contributed to the scientists' isolation from the public, it also generated a need for popularization to establish the authority of the new profession in the public sphere.[122] As Dirk J. Struik noted in his classic survey of science and technology in New England, numerous naturalists promoted their discipline by appealing to the value of utilitarianism.[123] "If the natural history of the colonial period was the quiet pursuit of the genteel and disinterested", argues Andrew J. Lewis in a recent examination of strategies employed by the American naturalists for establishing their discipline, "then early republic natural history […]

University Press, 1987; Philip J. Pauly, "The Appearance of Academic Biology in Late Nineteenth-Century America" *Journal of the History of Biology* 17 (1984): 369-97; Howard Plotkin, "Edward C. Pickering and the Endowment of Scientific Research in America, 1877-1918" *Isis* 69.1 (1978): 44-57; Norriss S. Hetherington, "Cleveland Abbe and a View of Science in Mid-Nineteenth-Century America" *Annals of Science* 33 (1976): 31-49; Sally Gregory Kohlstedt, *The Formation of the American Scientific Community: The American Association for the Advancement of Science, 1848–1860*, Urbana: University of Illinois Press, 1976; Nathan Reingold, "Definitions and Speculations: The Professionalization of Science in America in the Nineteenth Century" in *The Pursuit of Knowledge in the Early American Republic: American Scientific Societies from Colonial Times to the Civil War*, ed. Alexandra Oleson and S.B. Brown, Baltimore: Johns Hopkins University Press, 1976: 33-69.

120 George H. Daniels, *American Science in the Age of Jackson, 1815-1845*, New York: Columbia University Press, 1994 [1968].

121 John C. Burnham, *How Superstition Won and Science Lost. Popularizing Science and Health in the United States*, New Brunswick: Rutgers University Press, 1987, Chapter 4; George H. Daniels, *Science in American Society. A Social History*, New York: Alfred A. Knopf, 1971; Matthew D. Whalen and Mary F. Tobin, "Science, the Public and American Culture: A Preface to the Study of Popular Science" *Journal of American Culture* 4.4 (1981): 14-26; Deborah J. Warner, "Science Education for Women in Antebellum America" *Isis* 69.1 (1978): 58-67; Walter B. Hendrickson, "Science and Culture in the American Middle West" *Isis* 64.3 (1973): 326-340; Richard A. Overfield, *Science in the Virginia Gazette, 1736-1780*, Emporia: Kansas State Teachers College, 1968.

122 See George H. Daniels, "The Process of Professionalization in American Science: the Emergent Period, 1820-1860" *Isis* 58 (1967): 151-66.

123 Dirk J. Struik, *Yankee Science in the Making. Science and Engineering in New England from Colonial Times to Civil War*, New York: Dover Publications, 1991 [1948]: 336. See also Richard W. Judd, *The Untilled Garden. Natural History and the Spirit of Conservation in America, 1740-1840*, New York: Cambridge University Press, 2009, Chapter 8; Margaret Welch, *The Book of Nature: Natural History in the United States, 1825-1875*, Boston: Northeastern University Press, 1998; John C. Greene, *American Science in the Age of Jefferson*, Ames: Iowa State University Press, 1984.

was to be the public province of the interested – those curious about the natural world and those with something to gain" by participating in the production of this knowledge.[124]

Agricultural reformers took advantage of the widespread appeal of "useful knowledge" by focusing on practical implications of sciences relevant to farming. To the community surrounding the agricultural press, scientific education and agricultural improvement went hand in hand. "Let our younger farmers study the philosophy of botany, and [the doctrine of species transmutation] will soon become unfashionable", encouraged David Thomas, a recognized agricultural writer, in one of his vigorous arguments against transmutation.[125] In 1833, the *Genesee Farmer* published an address delivered by N. Goodsell to the Wheatland Agricultural Society, where speaking of the Linnaean classification system, Goodsell presented the value of botanical knowledge to practical farmers as he argued it "has done incalculable service" to agriculture. "It has rendered the propagation of plants, as plain and simple as that of animals, and subject to general rules", he said, and added: "It has forever dispersed the clouds of superstition and prejudice which had so long hung over this part of vegetable economy, and fixed it upon such principles that the success attending may be depended upon with the same certainty as with animals". According to Goodsell, the Linnaean order of species, varieties and genera rendered transmutation "as fabulous as that of the transmutation of animals; the remembrance of either serving only to remind us of the ignorance of ages past".[126] A similar argument prompted by the transmutation controversy appeared a few years later on the pages of the same periodical, where the author argued that "general principles" derived from botanical knowledge allowed younger readership to act as a "judge of the truth or error" in agricultural practice.[127] The author suggested plant systematics to be a valuable reference

[124] Andrew J. Lewis, *A Democracy of Facts: Natural History in the Early Republic*, Philadelphia: University of Pennsylvania Press, 2011: 48. For the emphasis on technology and crafts in popularization, see Hyman Kuritz, "The Popularization of Science in Nineteenth-Century America" *History of Education Quarterly* 21.3 (1981): 259-74. See also Irving H. Bartlett, *The American Mind in the Mid-Nineteenth Century*, 2nd ed, Hoboken: Wiley-Blackwell, 1982.

[125] David Thomas, "Cheat of Chess" *Genesee Farmer* v.2 1832: 174-5.

[126] "An Address" *Genesee Farmer* v.3 1833: 348-50.

[127] "Knowledge of Plants Applied to Farming and Gardening" *Monthly Genesee Farmer* v.2 1837-38: 36-8. The article was reprinted under the same title in the *Farmer's Register* v.5 1837-38: 17-9.

in determining the fallacy of species transmutation: "[I]f a farmer should hear the opinion advanced, that one plant might deteriorate, or in any way be transmuted into another plant, he should ascertain whether the two named plants belong to the same species or not; if they do not, he may be confident that such transformation can never take place".

Regarding the communication of scientific knowledge, the agricultural press fared better than American magazines. Even though periodicals served as the most prominent vehicle of popularization for general and specialized readers on both sides of the Atlantic, American magazines established with the aim of diffusing scientific knowledge were usually short-lived. It had not been before the creation of the *Popular Science Monthly* in 1872 that the American public could enjoy such a publication.[128] Another widespread popularization format was lectures given by respected scientists such as Amos Eaton or Benjamin Silliman at prestigious institutions, for instance, the Lowell Institute.[129] Scientific textbooks occupied a share of the popularization market as well. Among the less numerous publications on natural history, botany emerged as a favorite topic of American audiences eager to consume news about exotic plants and curiosities.[130] The most recognized botanical author was Erasmus Darwin, whose poetical renditions of the Linnaean botany were fashionable among upper-class women.[131] As a scientific discipline relevant to the problem of transmutation, nineteenth-century botany had thus attracted a significant amateur public.[132]

In his study of the history of American biology, Keith Benson remarked that the traditions of collecting, preserving, and describing natural specimens characterized the general approach towards nature employed by the American academic institutions.[133] In the 1830-40s, American botanists organized into a national network by Asa Gray were engaged in such a project of describing the

[128] Matthew D. Whalen and Mary F. Tobin, "Periodicals and the Popularization of Science in America, 1860-1910" *Journal of American Culture* 3.1 (1980): 195-203.
[129] Ibid, 136-8. See Margeret Rossiter, "Benjamin Silliman".
[130] Donald Zochert, "Science and the Common Man in Ante-Bellum America" *Isis* 65.4 (1974): 448-73.
[131] John C. Greene, "Science and the Public in the Age of Jefferson" *Isis* 49.1 (1958): 13-25; 17-8.
[132] Elizabeth B. Keeney, *The Botanizers: Amateur Scientists in Nineteenth-Century America*, Chapel Hill: University of North Carolina, 1992.
[133] Benson, "From Museum Research to Laboratory Research", 56-60.

American flora.[134] The gradual acceptance of natural systems of classification during the 1830s restricted the study of plants to academic botanists who nevertheless relied on networks of amateurs who supplied their collections, reflecting the complex social structure of the American natural history which brought together amateur naturalists, specimen dealers, museum curators, and men of science.[135] A recognized botanist and vigorous opponent of natural classification, Chester Dewey resisted the growing reservation of botany to scientific elites, bitterly remarking how "[t]he natural method takes botany from the multitude, & confines it to the learned".[136] Regardless, amateur botany flourished, and the demand for popular accounts had been met by works such as Almira Phelps's immensely popular *Botany for Beginners* and *Familiar Lectures on Botany* which ran through numerous editions and by 1867 respectively sold over 270,000 and 375,000 copies.[137]

In a recent examination of agricultural sciences among nineteenth-century agrarian communities, Benjamin Cohen noted that they "were more than disembodied laboratory endeavors, […] instead serving as signifiers of broader goals of improvement, knowledge, and political economic organization in the early Republic".[138] Before the emergence of the agricultural press, news about agricultural novelties had been distributed through almanacs, as well as newspapers, general-interest magazines, and treatises published by agricultural societies. Learned societies such

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134 Pauly, *Biologists*, 25-33.

135 Bruce, *The Launching of Modern American Science*, 119; Daniels, *American Science*, 38-9. During the antebellum period the scientific community had been extended to include significant participation of amateurs, see Daniel Goldstein, "'Yours for Science': The Smithsonian Institution's Correspondents and the Shape of Scientific Community in Nineteenth-Century America" *Isis* 85.4 (1994): 573-99; Sally Gregory Kohlstedt, "The Nineteenth-Century Amateur Tradition: The Case of the Boston Society of Natural History," in *Science and Its Public*, Gerald Holton and W A. Blanpied (eds.), Dordrecht: D. Reidel, 1976. For the history of American specimen dealers, see Mark V. Barrow, "The Specimen Dealer: Entrepreneurial Natural History in America's Gilded Age" *Journal of the History of Biology* 33 (2000): 493-534.

136 Qtd. in Daniels, *American Science*, 39. See also Charlotte M. Porter, *The Eagle's Nest: Natural History and American Ideas, 1812–1842*, Tuscaloosa: University of Alabama Press, 1986; Hyman Kuritz, "The Popularization of Science in Nineteenth-Century America" *History of Education Quarterly* 21.3 (1981): 259-74.

137 "Our Book Table" *Pennsylvania School Journal* v.15 1866-7: 296. See also Tina Gianquitto, *Good Observers of Nature: American Women and the Scientific Study of the Natural World, 1820-1885*, Athens: The University of Georgia Press, 2007; Emanuel D. Rudolph. "Almira Hart Lincoln Phelps (1793-1884) and the Spread of Botany in Nineteenth-Century America" *American Journal of Botany* 71. 8 (1984): 1161-7. For the status of women in the study of botany in England, see Ann B. Shteir, *Cultivating Women, Cultivating Science: Flora's Daughters and Botany in England, 1760-1860*, Baltimore: The Johns Hopkins University Press, 1996.

138 Benjamin R. Cohen, *Notes from the Ground. Science, Soil, and Society in the American Countryside*, New Haven: Yale University Press, 2009: 7.

as the Massachusetts Society for Promoting Agriculture or the New York Society for Promoting Agriculture, Arts and Manufactures, encouraged agricultural innovation by offering premiums granted to essays on agricultural topics, and exhibits shown during state fair competitions.[139] As Margaret Rossiter suggested, these societies performed a role which would later become the domain of professional bodies working towards the democratization of agricultural improvement such as agricultural colleges, state agricultural surveys, bureaus of the U.S. Department of Agriculture, or state experiment stations.[140]

Ever since its inception in 1819, the agricultural press served as the most significant medium for disseminating knowledge about sciences and technologies relevant to agriculture, in principle directing its contents to practical farmers. In a classic study of the history of the agricultural press, Albert Demaree estimated that by the 1840s, there were at least thirty agricultural periodicals in circulation among a 100,000 readers.[141] Who were the consumers of the agricultural press? In a study of the *Cultivator's* readership in Chenango County, Sally McMurry refined the existing historical assessments of these audiences, demonstrating that the majority of subscribers were well-off and decently educated farmers, not professionals and local tradesmen as Demaree's classic study had indicated.[142] By 1860, the national circulation of the American agricultural press reached an estimated 350,000, becoming the largest agricultural readership in the world.[143]

### 2.3 *Science in Agricultural Periodicals*

Scholarship exploring the history of the antebellum agricultural periodicals locates New York, Albany, and Boston, as major publication centers that attracted the greatest number of

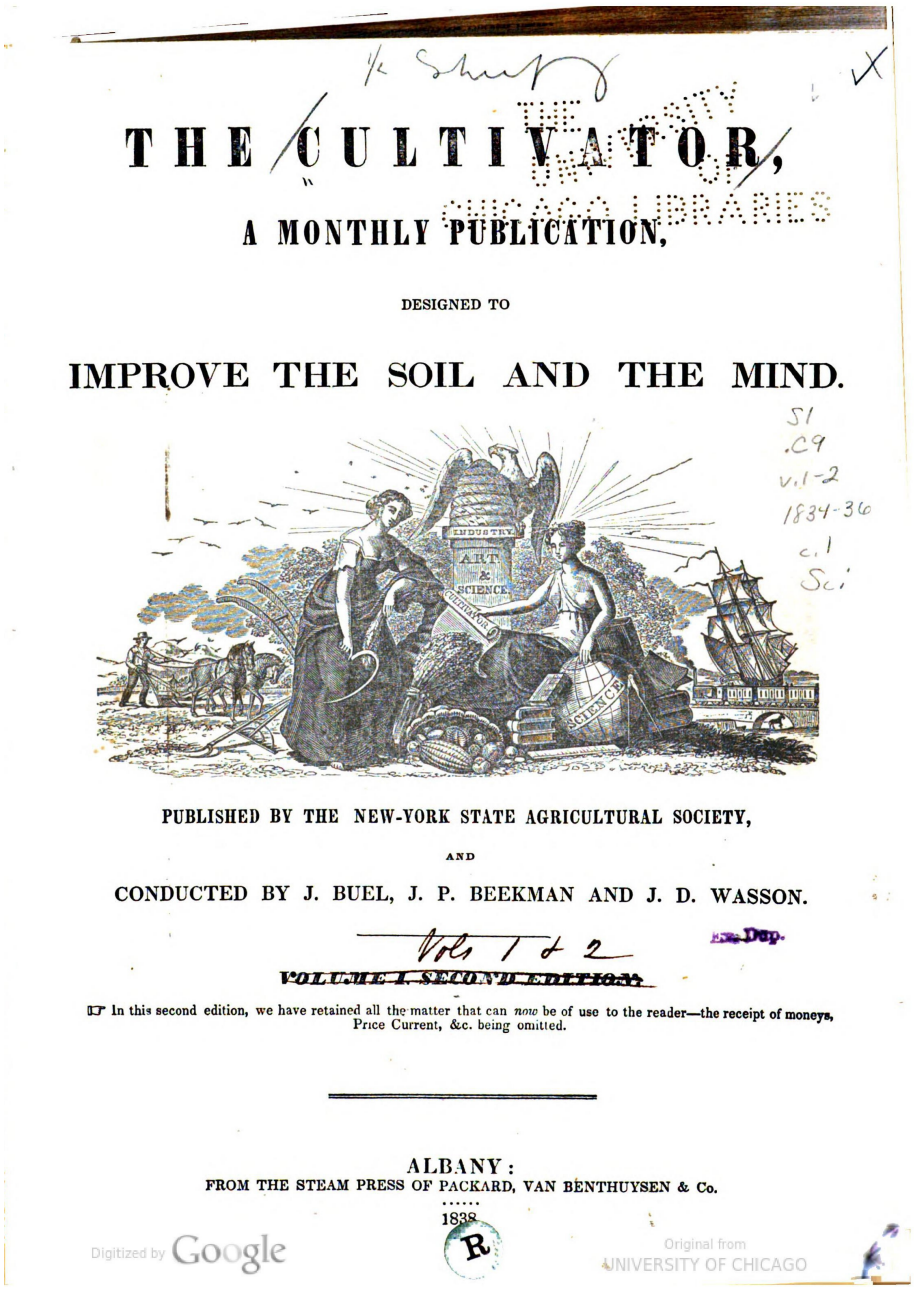
[139] For history of agricultural societies in the Northeast, see Donald B. Marti, *To Improve the Soil and the Mind: Agricultural Societies, Journals, and Schools in the Northeastern States, 1791-1865*, Ann Arbor: University Microfilms Intentional, 1979; Rossiter, "The Organization of Agricultural Improvement", 284-8.
[140] Rossiter, "The Organization of Agricultural Improvement", 279.
[141] Demaree, *The American Agricultural Press*, 17.
[142] Sally McMurry, "Who Read the Agricultural Journals?", 3.
[143] Danhof, *Change in Agriculture*, 56. Information about circulation is usually sourced from rough estimates reported by periodicals, see Demaree, *The American Agricultural Press*, 17-8.

readers, even if many periodicals had nationwide circulation. As a format, the agricultural journal emerged in 1819 with publications such as the *American Farmer* (1819-34), or the *Plough Boy* (1819-23), soon followed by the prominent *New England Farmer* (1822-46). Many of these journals were short-lived, but some enjoyed significant influence in disseminating information about topics such as crop rotation or agricultural chemistry to a considerable number of subscribers. One of such journals was the *Genesee Farmer* (1831-9), published and edited by Luther Tucker, a prominent figure in the early American agricultural journalism. Tucker created the weekly to provide a forum for knowledge exchange which he believed would fuel agricultural improvement in the Northeast. Featuring original articles penned by recognized American agriculturists, the *Genesee Farmer*, as John J. Thomas optimistically reported, had been considered as "especially adapted" to the needs of practical farmers.[144]

Tucker's editorial assistant was Jesse Buel, a judge and agriculturist who dedicated his career to demonstrating the benefits of "book farming". In 1834, Buel resigned from his position and founded a journal of his own, the *Cultivator.* Published under the motto "To improve the soil and the mind", the periodical served as Buel's vehicle for agricultural education (Figure 1). Upon his death in 1839, Tucker purchased the *Cultivator* and merged it with the *Genesee Farmer*, retaining Buel's original title and following the periodical with a modernized weekly, the *Country Gentleman*.[145] Meanwhile, Tucker's *Genesee Farmer* resurfaced in 1840, when a group of Rochester reformers published the *New Genesee Farmer*. At first claiming to bear no relationship with Tucker's discontinued journal, the periodical's editorship by authorities such as the educator Henry Colman, or the chemist Joseph Harris, guaranteed its status as the foremost publication in the area. Even if the editors who governed the agricultural press did not directly engage in farming activities, they belonged to an all-encompassing American culture of land cultivation.

[144] John J. Thomas, "Memoir of David Thomas: A Paper Read Before the Cayuga County Historical Society, December 17th, 1878" in Cayuga County Historical Society, *Collections of Cayuga County Historical Society*, Auburn, NY: Knapp, Peck and Thomson, 1887: 39-53; 49.

[145] For detailed accounts of the editorial history of these journals, see Demaree, *The American Agricultural Press*, Part III.



THE CULTIVATOR,

A MONTHLY PUBLICATION,

DESIGNED TO

IMPROVE THE SOIL AND THE MIND.

PUBLISHED BY THE NEW-YORK STATE AGRICULTURAL SOCIETY,

AND

CONDUCTED BY J. BUEL, J. P. BEEKMAN AND J. D. WASSON.

VOLUME I. SECOND EDITION.

☞ In this second edition, we have retained all the matter that can *now* be of use to the reader—the receipt of moneys, Price Current, &c. being omitted.

ALBANY:
FROM THE STEAM PRESS OF PACKARD, VAN BENTHUYSEN & Co.
1838.



Fig 1. Front page of *The Cultivator* v.1-2 1834-6. Credits: Public Domain, Google-digitized.

During the first half of the nineteenth century, the problem of species generation had been suppressed among the American naturalists as the scientific community did not permit such a controversial topic to enter their debate, or appear in scientific journals. The first successful

American scientific publication, Benjamin Silliman's *American Journal of Science and Arts*, referred to species transmutation only a handful of times between 1818 and 1859.[146] Since few individuals controlled such journals, excluding a scientist viewed as incompetent from publishing had been relatively effortless. Such was the case of Constantine Rafinesque, an eccentric naturalist, and enthusiastic taxonomist, who had been forced to establish a personal medium of communication for publishing accounts of the American flora.[147] As new classification systems competed to replace the old Linnaean organization, Rafinesque proposed a framework influenced by his radical evolutionary ideas, insisting on rapid evolution of species.[148] Rafinesque's evolutionism only lent support to the ill reputation he developed among naturalists with his zealous practice of taxonomy, described by Asa Gray in the naturalist's obituary as "a complete *monomania*".[149] Another naturalist who dared to publish his evolutionary views was Samuel S. Haldeman, a Pennsylvania zoologist and philologist, whose diplomatically expressed support of Lamarckian evolutionism did not, however, exclude him from the profession.[150] Haldeman and Rafinesque would later gain

[146] For examples of coverage, see "Mr. Hopkins's Opinion on the Transformation of Wheat Into Chess" *The American Journal of Science and Arts* v.1 1845: 308-9; Samuel George Morton, "Hybridity of Species, Considered in Reference to the Question of the Unity of Human Species" *The American Journal of Science and Arts* v.3 1847: 39-50.

[147] Jim Endersby, "'The Vagaries of Rafinesque': Imagining and Classifying American Nature" *Studies in History and Philosophy of Biological and Biomedical Sciences* 40 (2009): 168-78; Leonard Warren, *Constantine Samuel Rafinesque. A Voice in the American Wilderness*, Lexington: The University Press of Kentucky, 2004; Charles Boewe (ed), *Profiles of Rafinesque*, Knoxville: University of Tennessee Press, 2003. For the intersection of natural history and breeding, as well as history of generation and evolution, see Staffan Müller-Wille and Hans-Jörg Rheinberger (eds.), *Heredity Produced: At the Crossroads of Biology, Politics, Cutlure, 1500-1870*, Cambridge, MA: MIT Press, 2007, Part III and IV.

[148] At the height of the transmutation debate in agricultural press in 1832, Rafinesque had published the following statement: "The truth is that *Species and perhaps Genera also, are forming in organized beings* by gradual deviations of shapes, forms and organs, taking place in the lapse of time. . . . This is part of the great universal law of PERPETUAL MUTABILITY in everything . . . every variety is a deviation which becomes a Sp. as soon as it is permanent by reproduction" (qtd. in Warren, *Constantine Samuel Rafinesque*, 31)

[149] Qtd. in Endersby, "'The Vagaries of Rafinesque'", 168 (emphasis original). See also Daniels, *American Science in the Age of Jackson*, 59-61.

[150] Reporting from a meeting of the Association of American Geologists and Naturalists, Silliman's prestigious journal summarized Haldeman's paper on species distribution in molluscs, where the zoologist countered Charles Lyell's critique of Lamarck without offering solid proof either for or against the evolution ("Abstract of the Proceedings of the Fifth Session of the Association of American Geologists and Naturalists" *The American Journal of Science and Arts* v.47 1844: 99). *The Journal of the Boston Society of Natural History* did, however, point out that "[t]he author leans to the doctrine of transmutation, but we do not see the force of his reasoning, even to the limited extent to which he goes". The opinion from *The Journal of the Boston Society of Natural History* is summarized in "Bibliographical Notices" *The American Journal of Science and Arts* v.47 1844: 412-3.

recognition as the only American men of science included in Charles Darwin's historical sketch of evolutionary theories featured in the third edition of *On the Origin of Species*.[151]

Even though the vast majority of agricultural journals supported the anti-transmutationist side of the debate, editors allowed both proponents and opponents of transmutation to present their testimonies in hope of resolving the issue they deemed harmful to the agricultural practice.[152] Addressing an audience prejudiced against "book farming", the editors constructed an environment which encouraged a form of engagement with scientific knowledge that had been consistent with the expectations of practical farmers. These reformers thus drew on the tradition of fact collection and experimentation initiated in immensely influential works such as John Spurrier's 1793 *Practical Farmer* and John Binns's 1803 *Treatise on Practical Farming*.[153] As Clarence Danhof noted in a study of the development of Northeastern agriculture, amateur experiments carried out by small groups of farmers attracted considerable attention in the press and were particularly encouraged by agricultural organizations after 1840.[154] Periodicals promoted experimentally-proven innovations such as John Johnston's tile drainage practice, and disseminated news about experiments conducted by landowners in reports or letters. A similar experimental method had been suggested as the methodology for resolving the problem of species transmutation, as well as other unwanted superstitions such as moon-farming.[155]

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[151] For both mentions, see Charles Darwin, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life*, London: John Murray, 3rd edition, 1861: xvi. In a letter to Joseph Hooker, Darwin wrote of Rafinesque: "poor Naturalist as he was, he has good sentence about species & vars. which I must quote in my Historical Sketch", see Charles Darwin to Joseph Hooker, 29 December 1860, in *The Correspondence of Charles Darwin*, Volume 8 1860, Cambridge: Cambridge University Press, 1993: 541.

[152] For scientific content in agricultural press, see Cohen, *Notes from the Ground*, Chapter 2; Donald D. Marti, "Agricultural Journalism and the Diffusion of Knowledge: The First Half-Century in America" *Agricultural History* 54.1 (1980): 28-37.

[153] John Spurrier, *The Practical Farmer. Being a New and Compendious System of Husbandry, Adapted to the Different Soils and Climates of America. Containing the Mechanical, Chemical and Philosophical Elements of Agriculture. With Many Other Useful and Interesting Subjects*, Wilmington: Brynberg and Andrews, 1793; John Binns, A *Treatise on Practical Farming: Embracing Particularly the Following Subjects, Viz. the Use of Plaister of Paris, with Directions for Using It: and General Observations on the Use of Other Manures. On Deep Ploughing; Thick Sowing of Grain; Method of Preventing Fruit Trees from Decaying, and Farming in General*, Richmond: S. Pleasants, 2nd edition, 1804. For the influence of Spurrier on the rise of scientific agriculture, see Cohen, *Notes from the Ground*, 17-33.

[154] Danhof, *Change in Agriculture*, 53.

[155] For the debate about the impact of moon cycles on farming in agricultural periodicals, see Demaree, *The American Agricultural Press*, 38-9.

At the height of the transmutation controversy in the mid-1840s, the agent of the *Genesee Farmer* for Alabama, New York, remarked that the doctrine of transmutation did not "bear the test of experiment", or had been "supported by a solitary scientific fact or argument".[156] The transmutation debate generated a frantic search for such "scientific facts", and editors of agricultural periodicals responded to this need by frequently providing procedures for inducing transmutation and offering cash premiums for exhibits proving the doctrine's validity.[157] The readership answered the call for experimental testing of species transmutation with numerous accounts that reflected the democratic character of knowledge production promoted by the agricultural press. In the words of one contributor, it had been "the duty of every individual to contribute his mite to the general stock of information, experience or observation, to that community of which he is a member".[158] Due to the high volume of correspondence, editors often provided short summaries of incoming letters, or published articles which assembled news about recent experiments and proofs.[159] Even though the forty years-long debate attracted numerous farmers eager to prove transmutation, none of the premiums were ever claimed, demonstrating the rigor of editors in delineating the criteria for producing what they designated as "scientific" proof. The premium formula allowed editors to indirectly ridicule the doctrine as well. On one occasion, the reward offered for a "plant caught in the net of transmutation" reached an absurdly high sum of five hundred dollars, demonstrating the suspicion placed upon such a "philosophically, physically and mathematically impossible" theory.[160] In 1857, the editors of the *Cultivator* established a scientific committee composed of the

[156] R. B. Warren, "Transmutation of Plants" *[New] Genesee Farmer* v.10 1849: 63.

[157] For examples of procedures for inducing species transmutation, see "Modes of Transmuting Wheat to Cheat" *Farmer's Register* v.9 1841: 482-3; "Transmutation" *Cultivator* v.1 1844-5: 322. For examples of premium offerings, see "The Fifty Dollar Premium" *Genesee Farmer* v.2 1832: 353; J. M. G., "On the Cheat Controversy" *Farmer's Register* v.2 1835: 407-9; "Modes of Transmuting Wheat to Cheat" *Farmer's Register* v.9 1841: 482-3; "Transmutation" *Cultivator* v.1 1844-5: 344; "Wheat Turning to Chess" *Country Gentleman* v.7 1856: 32; "Wheat Turning to Chess" *Cultivator* v.4 ser.3 1856: 67; "Wheat Turning to Chess" *Country Gentleman* v.10 1857: 128; "Chess in Wheat" *Cultivator* v.5 ser.3 1857: 228-9; "Wheat and Chess" *Cultivator* v.7 ser.3 1859: 193.

[158] Robert Batts, "Causes of Spelt and Cheat in Wheat" *Farmer's Register* v.2 1835: 162.

[159] For examples of editorial summaries or letters listing transmutation experiments, see: David Thomas, "What Is Cheat or Chess?" *Genesee Farmer* v.2 1832: 273; D. T. [David Thomas] "Chess" *Genesee Farmer* v.3 1833: 83-4; "Note by the Editors" *Cultivator* v.7 1840: 128-9; "Culture of Wheat" *Cultivator* v.9 1842: 163; "Wheat and Chess" *Cultivator* v.6 ser.3 1858: 306.

[160] "Chess – Transmutation" *Genesee Farmer* v.10 1849: 132.

botanist and educator Chester Dewey, the prominent agricultural writer John J. Thomas, and B. P. Johnson, the secretary of the New York State Agricultural Society, who were to examine samples sent in by subscribers lured by the premium (Figure 2).[161]

"[E]very few years the question was agitated, and it always resulted, by the experiments of those who were clear of prejudice, [...] that wheat would not turn to cheat", wrote of the controversy the recognized viticulturist John Adlum.[162] In his letter to the *Genesee Farmer*, Adlum referred to Joseph Cooper, a famous seedsman mentioned in Erasmus Darwin's *Phylologia*, whose experiments convinced him of the doctrine's fallacy, suggesting that properly obtained experimental findings could serve as a remedy against such superstitions. Editors played an active role in the transmutation controversy not only by curating content that appeared on the pages of periodicals, but also by conducting experiments themselves. In 1832, the editor of the *Farmer's Register*, Edmund Ruffin, together with two associates gave account of the first experiment intended to offer proof against transmutation that would later become a common reference for anti-transmutationists.[163] When arguing against species transmutation, contributors emphasized the authority of such experiments, stating that it had been easier to believe in transmutation, than "to examine, investigate, and practically test the truth of any received opinion".[164] Experiments intended to prove the doctrine had been valued negatively as tainted by prejudice and ambiguity, so "that minds habituated to close reasoning could place no confidence in the results".[165]

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[161] See "Wheat Turning to Chess" *Country Gentleman* v.10 1857: 128. For proceedings of the committee, see *Transactions of the New York State Agricultural Society*, Albany: Charles Van Benthuysen, 1859: 304-9.

[162] John Adlum, "Letter from Maj. John Adlum" *Genesee Farmer* v.4 1834: 110-1. For biographical information about John Adlum, see Tomas Pinney, *A History of Wine in America. From the Beginnings to Prohibition*, Berkeley: University of California Press, 1989: 139-49. There are no recent sources available on Joseph Cooper, see Liberty Hyde Bailey, *The Survival of the Unlike. A Collection of Evolution Essays Suggested by the Study of Domestic Plants*, New York: The Macmillan Company, 1906: 151-5.

[163] For Ruffin's experiment, see "The Supposed Transmutation of Wheat Into Cheat" *Farmer's Register* v.9 1841: 11-13. For a biography of Edmund Ruffin, see David F. Allmendinger (ed.), *Incidents of My Life: Edmund Ruffin's Autobiography*, Charlottesville: University Press of Virginia, 1990, Betty L. Mitchell, *Edmund Ruffin: A Biography*, Bloomington: Indiana University Press, 1981. For significant references to the experiments during the debate, see Robert Batts, "Causes of Spelt and Cheat in Wheat" *Farmer's Register* v.2 1835: 162; J. M. G. "On the Cheat Controversy" *Farmer's Register* v.2 1835: 407-9; "Cheat or Chess" *Monthly Genesee Farmer* v.1 1836-7: 85-6; James M. Garnett, "Disputed Questions in Agriculture" *New Genesee Farmer* v.2 1841: 146-7.

[164] "Cheat" *Genesee Farmer* v.5 1835: 374.

[165] "Chess" *Monthly Genesee Farmer* v.1 1836-7: 122.

## New Advertisements.



### Public Sales of Stock.

SHORT-HORN CATTLE AND LEICESTER SHEEP, belonging to the late RALPH WADE, Aug. 26, near Cobourg and Port Hope, Canada West.

DEVON CATTLE AND SOUTH DOWN SHEEP—of LEWIS F. ALLEN, at Grand Island, N. Y., Sept. 9

SHORT-HORN CATTLE, SHEEP AND PIGS—of F. W. STONE, at Moreton Lodge, Guelph, C. W., Sept. 16.


# The Country Gentleman.

ALBANY, AUGUST 20, 1857.


WHEAT TURNING TO CHESS.—Some months ago, to settle a controversy on this subject, BENJAMIN HODGE of Buffalo, offered a premium of *one hundred dollars* to any one who would demonstrate that wheat would turn to chess—to be awarded under the supervision of the New-York State Agricultural Society, and under such rules as a Committee appointed by the Society should prescribe. This premium was lately claimed by SAMUEL DAVIDSON, of Greece, Monroe Co., N. Y., who had in his possession, as he believed, the evidence of transmutation. A Committee, appointed by the Society, consisting of Prof. DEWEY and L. B. LANGWORTHY, of Rochester, and J. J. THOMAS, of Union Springs, with Col. JOHNSON, Sec. of the Society, met at Rochester recently to examine the evidence.

The experiment to prove transmutation was the following:—A quantity of earth was passed through a fine seive, to separate all chess seeds. It was placed in a pan, and several heads of wheat planted in it. When the wheat came up, it was subjected to all the hard treatment that usually produces winter-killing, viz., flooding with water, and alternately freezing and thawing for several times. Late in the spring, the whole contents of the pan were removed and set out in open ground. When the plants of wheat threw out their heads, there appeared chess heads also. This mass of wheat and chess plants was brought in and placed before the Committee. Stalks of chess were shown, the roots of which were found to proceed directly from the planted heads of wheat, which yet remained entire, and in some instances they were found to issue from the half decayed grains of wheat themselves. This was looked upon as conclusive.

The roots were taken by the Committee and first soaked in water, and afterwards gently washed, by moving them backwards and forwards slowly through it. They were then carefully examined by microscopes. The roots of the chess were now perceived to issue, not from near the end of the grain of wheat, as is usual in sprouting, but from the *side*, and in fact from almost any part. Further examination showed that they merely passed *through* crevices in the decayed wheat grains, and they were separated from the grains without tearing, being merely in contact, without any adhesion or connection. Some of the more minute chess fibres were observed by an achromatic microscope, to extend over the inner surface of the bran, where they had gone in search of the nourishment, (which is known to abound just within the bran,) in the same way that grape roots have been observed to spread over the surface of a rich decaying bone. But they easily separated, and had no connection with the grain. It was satisfactorily proved that the chess plant could not have come from these grains, by the fact that the same single stalk of chess was thus connected with five or six different grains,—which could no more have originated it, than five or six cows could have one calf. This examination, therefore, did not prove anything in favor of transmutation; and as there were many possible ways in which the chess might have become scattered on the soil, the whole experiment was admitted by all parties to be inconclusive.

The claimant is, however, perfectly "satisfied" that the wheat turned to the chess; and he is also so well satisfied with the candor and accuracy of the Committee, that he is confident he will yet convince them of the fact of transmutation, as experiments, conducted by them with great care, are to be performed under his direction, another year.

THE ENGLISH AG. SOCIETY'S MEETING FOR 1857.—The nineteenth meeting, held at Salisbury, during the week ending 25th July, appears to have been generally very successful, although we notice that some quite severe strictures have appeared upon the details of its management. The attendance, it is stated, will "put the exchequer of the Society in a better position than it has been for years." The entries of stock were 1185, about one-fourth—and those of implements about one-sixth, larger than on any previous occasion, and the excellence of the show, as a whole, is the subject of favorable comment—particularly as regards live stock. "The Society never at any previous meeting presented a more gratifying sight, than in the display of cattle, sheep, and pigs." We have not room to notice the exhibition, or the exhibitors at length. It appears that Mr. Fawkes of Farnley Hall, York, occupied a very prominent position among Short-horn breeders—for the fourth time taking the first prize for yearling bulls, and having also been the breeder of the first prize bull in the class including all between 2 and 4 years. Colonel Towneley was again successful in the class for cows, carrying off both prizes, as he did last year. The show of Herefords was good, and that of Devons larger and better than in 1856. "In sheep, the show of Leicesters and Cotswolds was superior, the Cotswold breed having never been better represented. The Southdowns were also excellent, Mr. Jonas Webb distancing all competitors." Blood and well-bred horses are said to have been fairly represented—but other classes not well filled. Pigs were very fine.

In Implements the Society offer an example worthy of imitation here, by limiting the prizes each year to a particular department, and only making awards on fair and careful trials. At Chelmsford, in 1856, plows, harrows, and rollers were the especial articles of competition. This year, £155 were set aside as premiums for drills and horse-hoes, hay machines and rakes, reaping and mowing machines, and carts and wagons. £500 was also to be awarded to the best steam cultivator. The first prize for Reapers was taken by McCormick's machine, made by Burgess & Key—for Mowers by the "American Eagle" made by Ruggles, Nourse & Mason, and the same patent which took the $1000 prize last year in Massachusetts, but which since appears in this country to have failed to maintain the high reputation then acquired.

Four Steam Cultivators were tried but no prizes awarded. There was much complaint as to the character of the field selected for the trial, for which a high price was paid, but which proved in soil flinty and baked, as well as so steep as to be entirely unsuitable.

THE TARIFF AND THE PRICE OF WOOL.—A writer in the Cleveland Wool Grower, says

"It is now over one month since the new tariff regulations took effect. Previous to the 1st of July, it was asserted by many whose opinions were entitled to the highest consideration, that the result would be a depreciation in the value of our domestic wools, to be caused by excessive importation of the foreign article. Whether those parties were sincere in their assertions, it is not for me to say."

We should like to have this writer enlighten us on the effects of duties on imports. If the manufacturer could import foreign wools at lower prices than he pays for domestic, would he not do it, and would not that reduce the price of the home-grown article to the price at which the foreign could be imported? If the duty does not affect the price of an article, why all the clamor about the duties on iron, cloths, &c. If a duty does affect the price of iron and broadcloth, why does it not affect the price of wool and wheat? The prices of all these articles are regulated in this country by the sums they will sell for in New-York. Now, if any one of them can be brought from abroad, and sold for a less sum than that at which the domestic article is selling, will not the price of the latter be reduced to that at which the foreign can be sold, and will not a duty of 20 or 30 per cent. add just so much to the price of the imported article? The price of wool has not been reduced this year, simply because it can not be imported, owing to its scarcity abroad, at a cheaper rate; but suppose the manufacturer could import such wool as he now pays the farmer 50 cents for, at a cost of 40 cents, will any one pretend that the farmer would not have to sell his at a reduction of 10 cents per pound?

PREMIUM LISTS.—We have received the Premium Lists of the Michigan, Illinois, Pennsylvania, and Iowa State Ag. Societies—also the Lists of the St. Lawrence International, Palmyra Union, Delaware County, Rutland Co, (Vt.) and Windham Co. (Ct.) Ag. Societies.

WILSON STRAWBERRY.—Our thanks are due to JOHN DINGWALL, for a package of the plants of this new and admirable strawberry, received recently in excellent condition.

AGRICULTURAL FAIRS.—We publish on the last page of this paper, lists of State and County Fairs (for several of the States,) as correct and complete as we have the means of making them, and shall be greatly obliged to any one who will make any corrections necessary in the lists, or add to them.

CATTLE SALES.—We have received the Catalogue of Short-Horn Cattle, Cotswold and South Down Sheep, and Berkshire and Yorkshire Pigs, to be sold at Moreton Lodge, Guelph, Canada West, Sept. 16. See advertisement.

☞ It will be seen by a notice in this paper, that a large addition has been made to the stock of Short-Horns to be offered at public sale at the farm of the late Ralph Wade, near Cobourg, C. W., on Wednesday of next week.

☞ The stock imported by the Illinois Importing Association this summer, consisting of 21 cows and heifers, and 10 bulls, (Short-Horns,) 25 Cotswold and South Down sheep, and 23 Berkshire, Irish and Cumberland pigs, are to be sold at Springfield, Ill., on the 27th inst.

FRANCE, ENGLAND AND AMERICA ON THE TURF.—By the last steamer we have tidings of the much talked of races for the Goodwood Cup, for which it appears that 14 horses ran—among them the French horse *Monarque*, and the American *Prioress* and *Pryor*. *Monarque* was the winner by a head, and Risober the second, beat Fisherman the third, both English horses, by about three lengths. Anton was placed fourth, and was three lengths behind Fisherman. The American Horses, Pryor and Prioress were placed fifth and sixth, and the English horse Melissa seventh. All the others pulled up. A short time after starting Prioress took the lead, and kept it until on rounding the first turn she unfortunately ran wide. The London Times report states that according to general opinion, "the American horses might have figured still more prominently, had they been entrusted to men as experienced and accomplished in their profession as English Jockeys. Indeed, in turf phraseology, Prioress looked all over the winner at the distance. The French people present were not a little gratified by the success of MONARQUE, and the prize which they will carry with them to France is a trophy worthy of possession." The defeat of the American horses is not without the consolation of a good many compliments, and it is hoped they may be more successful in their future engagements

FRUIT GROWERS' SOCIETY OF WESTERN NEW-YORK. AUTUMNAL EXHIBITION.

The Autumnal Exhibition and meeting of the Fruit Growers' Society of Western New-York, is to be held at the City Hall in Rochester, on the 18th and 19th days of 9 mo. (Sept.) next. A strong effort will be made to render this one of the most interesting meetings of this kind ever held in this country—the comparatively promising crop of fruit through a large portion of western New-York, and the extensive specimen grounds of many cultivators in this district, furnish eminent advantages for a large pomological diplay. All who are interested, both in western New-York and elsewhere, are cordially invited to attend—and this invitation is especially tendered to those without the district embraced by the Society, and in other States.

Horticultural editors would confer a favor by copying the above.

☞ North-western Fruit Growers' Association, meet at Alton, Ill., September 29.



Fig 2. Report of the activities of the Committee appointed by the New York State Agricultural Society for the assessment of experiments presented by contributors to the journal ("Wheat Turning to Chess" *Country Gentleman* v.10 1857: 128). Credits: Public Domain, Google-digitized.

The focus on experimentation which sustained the transmutation controversy had been embedded in a public culture of science that placed an emphasis on exhibition and practical demonstration of scientific knowledge. Institutions ranging from Charles Willson Peale's Museum in Philadelphia to P. T. Barnum's sensational American Museum allowed the general public to view natural exhibits organized into collections of domestic and exotic specimens.[166] An opponent of species transmutation suggested that had the doctrine been true, samples of wheat undergoing transmutation would haven been exhibited together with other items farmers could see on annual fairs and gatherings of local community clubs.[167] Editors who examined proofs submitted by readers had been well-aware of the degree to which such exhibits could mislead the public opinion. During the peak of the transmutation controversy in the early 1830s, the editors of the *Genesee Farmer* were presented with a sample that had been evidently displayed for public viewing. "From the fly specks upon the specimen, we inferred that it had been kept for exhibition a long time", they concluded. An examination with a magnifying glass revealed the deceptiveness of the exhibit, as the spectators "by simply looking at it with the naked eye could not discover but what the chess belong to the same stalk as the wheat". Inevitably, "hundreds must have been convinced of the doctrine of transmutation by this alone".[168] Contributors who participated in the transmutation debate frequently contrasted the ordinary visual observation and practical experience of farmers with "scientific" methods of examination involving technologies such as a magnifying glass or microscope. The transmutation debate had thus served as a forum for negotiating the status of scientific expertise for the study of nature.[169]

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166 See David R. Brigham, *Public Culture in the Early Republic: Peale's Museum and Its Audience*, Washington, DC: Smithsonian Institution Press, 1995; Joel J. Orosz, *Curators and Culture: The Museum Movement in America, 1740-1870*, Tuscaloosa: University of Alabama Press 1990; Charles Coleman Sellers, *Mr. Peale's Museum; Charles Wilson Peale and the First Popular Museum of Natural Science and Art*, New York: W. W. Norton, 1980; Toby A. Appel, "Science, Popular Culture, and Profit: Peale's Philadelphia Museum" *Journal of the Society for the Bibliography of Natural History* 9 (1980): 619-34.

167 "Wheat vs. Chess" *Cultivator* v.1 1844-5: 66-7.

168 "Chess" *Genesee Farmer* v.2 1832: 353.

169 For examples of microscope use, see "Convertibility of Wheat Into Cheat, or Chess" *Farmer's Register* v.3 1835: 431-2; "Wheat and Chess" *Country Gentleman* v.12 1858: 153. For the popularization of microscopy, see John H. Warner, "'Exploring the Inner Labyrinths of Creation': Popular Microscopy in Nineteenth-Century America" *Journal of the History of Medicine and Allied Sciences* 37 (1982): 7-33.

## 2.4 *Constructing the Authority of Science*

"The Botanist, whose observations are incomparably more close and accurate than the assertors of this doctrine, would no sooner admit [chess] to be a degeneracy of nature, because it grows in our wheat field, than the Zoologist would admit the a to be the degenerate offspring of the cow because they feed in the same pasture […]".[170] This very first public pronouncement against the doctrine of transmutation had already indicated the superiority of botanists over farmers in the study of nature. David Thomas's speech defined the central focus of the debate about species transmutation which would unfold during the next forty years, illustrating a clash between two contrasting types of knowledge produced through different interactions with the environment. A contributor to the *Cultivator* noted that the controversy had been powered by a heated conflict between "[t]he 'book men' claiming the transmutation of wheat into chess to be a violation of the laws of nature, and the practical farmers maintaining that the severity of winter changes wheat into chess".[171] This had been valid of the transmutation debate until the late 1830s, when some of the "book men" who contributed to the discussion began to support species transmutation, thus destabilizing the divide between farmers and learned men which had characterized the antebellum agrarian community.[172]

The transmutation controversy exploded in the early 1830s with the publication of an article penned by an exemplary agricultural reformer and editor, David Thomas. Thomas was a Pennsylvanian Quaker and polymath who dabbled into civil engineering, geology, horticulture, and agricultural writing, contributing over eight hundred articles and shorter pieces to the *Genesee Farmer* during the first six years of the journal's operation.[173] Thomas began his argument against

[170] David Thomas, "An Address Delivered Before the Agricultural Society of Cayuga, at Their Anniversary Meeting Held on the 7th Day of February, 1820" *Plough Boy* v.1 1820: 316.
[171] "Knocks on a Farm" *Cultivator* v.2 ser.2 1845: 91.
[172] See Cohen, *Notes from the Ground*, Chapter 2; Rossiter,"The Organization of Agricultural Improvement".
[173] For biographical information on David Thomas, see John Jacob Thomas, "Memoir of David Thomas"; William Thomas Lyle, *The Thomas Family, as Descended from David and Anna Noble Thomas*, Union Springs: J. B. Hoff, 1908: 25-34. For a recent mention, see Hugh Barbour, *Quaker Crosscurrents: Three Hundred Years of Friends in the New York Yearly Meetings*, Syracuse: Syracuse University Press, 1995: 240.

transmutation by stating that only "uncultivated minds" would accept the theory; "a notion so pernicious, so preposterous, and so nearly allied to superstition, [that] has infected the minds of our countrymen; and blinded our farmers to their true interests".[174] "[T]hose who have never studied, nor understood the immutable boundaries between plants of different genera and species, should not perceive the absurdity of wheat turning into chess", he pointed out. Thomas had not been alone in granting authority to botanists over the matter. Another contributor characterized this group as "the only persons qualified to describe the plant and to show its affinities to other plants".[175] Thomas's view found opposition in a letter from Gideon Ramsdell, the member of the Monroe County Agricultural Society.[176] Sharing his personal observations of transmutation, Ramsdell concluded the transformation of wheat into chess had been of "natural consequence".[177] This statement enraged Thomas, who followed the letter with two lengthy articles where he presented sophisticated argumentation against transmutation on the basis of historical sources such as John Gerard's 1597 *The Herbal*, which he claimed did not offer any accounts of wheat turning into chess.[178]

Ramsdell's ensuing response pushed the discussion further into this avenue when he invoked the widespread opposition to "book farming" and openly rejected the authority of science in agricultural matters: "who are to be believed in this discussion, either observing, practical farmers, who have occular demonstrations of their own experiments, or chimical [sic] men, who know more about eating wheat than growing it?".[179] Thomas's response was even more vigorous: "[Ramsdell] presumes that I am not a *practical farmer*, and seems to insinuate that I must consequently be disqualified to enter into debate among *practical farmers*", he objected.[180] Remarking on the

[174] David Thomas, "Cheat of Chess" *Genesee Farmer* v.2 1832: 174-5.
[175] David Thomas, "Wheat is Cheat or Chess?" *Genesee Farmer* v.2 1832: 269-70. For other examples, see "The Opinion of Judge Peters on Cheat or Chess" *New England Farmer* v.10 1831-32: 78; "Chess" *Genesee Farmer* v.2 1832: 364; "Cheat or Chess" *Monthly Genesee Farmer* v.1 1836-7: 65-6; "Is Wheat Convertible Into Cheat?" *Farmer's Cabinet* v.2 1838: 322-4.
[176] See *Transactions of the New York State Agricultural Society*, Albany: E. Mack, 1843: 352-3.
[177] Gideon Ramsdell, "Wheat Turning to Chess" *Genesee Farmer* v.2 1832: 242-3.
[178] David Thomas, "Chess" *Genesee Farmer* v.2 1832: 300-1; ibid, "Chess" *Genesee Farmer* v.2 1832: 318-9.
[179] Gideon Ramsdell, "My Motto Is – Will Wheat Turn Into Chess?" *Genesee Farmer* v.2 1832: 326.
[180] David Thomas, untitled article, *Genesee Farmer* v.2 1832: 358.

rhetorical effect of the term "practical farmer", Thomas once again addressed the problem of authority in agriculture by suggesting that only those who study nature scientifically may consider themselves adequately prepared to resolve the problem of transmutation. "Sir Humphrey Davy was not a *practical farmer* when he lectured on Agriculture; but the most intelligent *practical farmers* in England looked up to him for instruction", he argued. Thomas strengthened his argument with observations about chess supported by works of eminent botanists such as William P. Barton, Asa Gray, or John Torrey. The heated debate between Ramsdell and Thomas set a specific tone on negotiating the professional authority of botanical science over the study of natural phenomena relevant to the practice of agriculture which underwent a transformation with the introduction of scientific knowledge and technological artifacts. In the context of the transmutation debate, the problem of botany's authority required careful deliberation, as one contributor to the *Cultivator* suggested: "That science, and the study of agricultural works and periodicals are a great aid to the farmer, there is no question. Yet there are facts, and some important ones, which are almost daily developed to the practical and observing farmer, which might in vain be sought for in the pages of science, or the works of the theorist".[181]

By the mid-1830s, the clear-cut opposition of opinions held by practical farmers and men of science began to blur. In an address to the Dorchester Agricultural Society, the chemist and tobacco grower Joseph E. Muse depicted agriculture as a natural science and proceeded with a presentation of "the doctrine of progressive improvement and transmutation", at first referring to geological findings, only to follow with a comment on species transmutation.[182] The transformation of wheat into another grain species, Muse argued, "is consistent with experience and daily observation", positioned "against the bold assertions and inveterate dogmas of adversary opinionists" who "hold their creed of physiology as a code of moral law". As expected, the address generated a lively

[181] J. F. Chubb, "Transmutation of Wheat into Chess" *Cultivator* v.7 1840: 198.
[182] Joseph E. Muse,"Address to the Dorchester (Md.) Agricultural Society" *Farmer's Register* v.5 1837-38: 539-46.

response across the agricultural press.[183] Referencing the work of Jean Baptiste Lamarck and Charles Lyell, Muse stated that sufficient proof for transmutation had been presented by an American geologist, "Mr. Featherstonhaugh […] whose acute observation, and high and well-merited fame, and acquirements in the natural sciences, are ample pledges of its accuracy". George William Featherstonhaugh was a British geologist who had been employed by the United States government to examine the newly-purchased Louisiana territory.[184] Readers of the periodical who followed the transmutation debate would recall a feature published two years prior which included a lengthy reprint of an article Featherstonhaugh wrote for his publication, the *Monthly American Journal of Geology and Natural Science*.[185] Featherstonhaugh admitted that the common disbelief in transmutation had been "a very natural, and perhaps, a very useful one to entertain" as it motivated farmers to carefully select and clean their wheat seed. Nevertheless, Featherstonhaugh proceeded with an account of proof presented to him while on a geological excursion in Virginia. Having examined the specimen under a microscope, Featherstonhaugh concluded that a plant of chess had indeed sprang from a kernel of wheat and constituted a clear proof of species transmutation.

Featherstonhaugh's account marked the beginning of a change in public expositions of scientific authority over the understanding of nature. A proof of transmutation delivered to the *Cultivator* had convinced the journal's editor and renowned agricultural writer, Jesse Buel, of the potential validity of the doctrine. His tentative belief that chess originated from diseased wheat, inevitably leading to "the overthrow of the Botanical Science", had been controversial because Buel belonged to the social circle of the learned men, leading other editors to fear that "[p]ossibly indeed, [the *Cultivator*] may pin some part of his faith on to the sleeves of many practical farmers".[186] What

[183] See "Dr. Muse's Dorchester Address" *Genesee Farmer* v.8 1838:11-2; "Exceptions to Some Positions in Dr. Muse's Address" *Farmer's Register* v.5 1838: 610-1; "Remarks on the Exceptions to Dr. Muse's Address" *Farmer's Register* v.6 1838: 78-9.

[184] For biographical information, see Edmund Berkeley and Dorothy Smith Berkeley, *George William Featherstonhaugh. The First U.S. Government Geologist*, Tuscaloosa: University of Alabama Press, 1988.

[185] "Convertibility of Wheat Into Cheat, or Chess" *Farmer's Register* v.3 1835: 431-2. For the original article, see George W. Featherstonhaugh, "Convertibility of Wheat Into Cheat or Chess" *The Monthly American Journal of Geology and Natural Science* v.1 1831-2: 561-3.

[186] "Wheat Turning Into Chess" *Monthly Genesee Farmer* v.1 1836-7: 161-2.

outraged editors was the nonchalance with which the *Cultivator* suggested that "the opinions have been equally confident upon *both sides*" of the controversy.[187] In response to this criticism, the *Cultivator* offered a simple solution: either naturalists erroneously classified chess into a different family of grains, or that "there are exceptions to general laws in vegetable physiology".[188] Muse, Featherstonhaugh, and Buel had thus disrupted the clear distinction in views on species transmutation which had characterized the early years of the debate.

In 1838, a contributor to the *Farmer's Register* lamented that "facts are wanted: such facts as no scientific investigator could question […] offered to the observation of men of science".[189] The following years witnessed a flood of criticism directed against the doctrine of transmutation, considered an "agricultural heresy of first magnitude" and criticized for "its palpable unsoundness, its contravention of the known laws that govern vegetation, and its direct contradiction to inspiration, as on account of the bad effects it must have on farming of all who embrace it".[190] This type of discourse appeared in a letter which launched another round of debate. In his contribution to the *New England Farmer*, J. Townsend offered a vigorous response to an article published by the eminent British botanist, John Lindley, in the *Gardeners' Chronicle*, reprinted on the first page of the *New England Farmer* (Figure 3). Lindley admitted that after noting "accidental variations" springing up among orchidaceous plants, he and other botanists adhered the "orthodox faith in the matter of species", but were prepared to admit that the hereditary pattern of these plants may be extrapolated to grains, "for it is not likely that such vagaries will be confined to one little group in the vegetable kingdom: it is far more rational to believe them to be a part of the general system of creation".[191] Lindley urged for more experimentation intended to determine the means by which oats, wheat, barley, and rye could change into one another.

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[187] Ibid.
[188] "Chess or Cheat" *Cultivator* v.3, 2nd ed, 1836: 88.
[189] "Exceptions to Some Positions in Dr. Muse's Address" *Farmer's Register* v.5 1838: 610-1.
[190] "Wheat vs. Chess" *Cultivator* v.1 1844-5: 66-7.
[191] "Transmutation of Grain" *New England Farmer* v.23 1844: 161.

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TRANSMUTATION OF GRAIN.

☞We are not among those who believe in the transmutation of grains, or the changing of one kind into another—a doctrine which, however, has many strenuous supporters. But since the subject is one upon which sensible men differ in opinion, whatever can be said in favor of either side, is entitled to a candid hearing and unbiassed judgment. Though we are disposed to pronounce, and often have pronounced, the transmutation doctrine *absurd*, this does not *make* it so—and we are inclined to give any thing that may be brought forward in its support an attentive consideration. The following article on the subject is copied from the London Gardeners' Chronicle, of which journal, Prof. Lindley, the learned botanist, is associate editor. If the question of transmutation was really so absurd an one as even we ourselves have considered it, the discussion of it, we think, would not have been admitted in the columns of a paper with which such a distinguished botanist as Prof. L. is connected. In the article below, it is virtually admitted that the doctrine *may* be true, as it is recommended that experiments be tried to settle the question "whether, by any means, wheat, oats, barley and rye, can be made to change into each other." The *Chronicle* gives a quotation from an old writer on the subject, (Gerarde,) with which we commence our extracts:—

"I think it a very fit thing," says worthy Master Gerarde, "to adde in this place a rare observation of the *transmutation* of one species into another in plants; which, though it have beene observed in ancient times, as by Theophrastus, 'De Caus. Plant.' lib. 3, c. 16, whereas among others hee mentioned the change of Spelt into Oates, and by Virgil in these wordes—

"In furrows where good barley we did sowe,
Nothing but Darnell and poor Oates did growe."

"Yet none that I have read have observed that two severall graines, perfect in each respect, did growe at any time in one eare; the which I saw this yeare (1632) in an eare of White Wheat, which was found by my very good friend, Mr John Goodyer, a man second to none in his industrie and searching of plants, nor in his judgment or knowledge of them. This eare of Wheat was as large and faire as most are, and about the middle thereof grew three or four perfect Oates in all respects; which being hard to be found, I hold very worthy of setting downe, for some reasons not to be insisted on in this place."

What the good Gerarde's 'reasons not to be insisted on' may have been, (says the *Chronicle)* we are unable to discover. Perhaps he was afraid of being laughed at as a dreamer; or, may be, he dreaded an indictment for heresy. *Then,* (it is to be imagined,) as now, the doctrine of the transmutation of grain was laughed to scorn; and we have numbered ourselves among the scorners.

But are the scorners *right?* Are we so *very* sure that one kind of grain has not been formed accidentally from another—that no room is left for argument or evidence? Some years ago, we should have said yes; we now say no. We now say, that we are not so *very* sure about the matter, although we do still hold hard to the orthodox faith in the matter of species. What has unsettled our belief, and changed us from skeptics into doubters, is the extraordinary but certain fact, that in orchidaceous plants, forms just as different as wheat, barley, rye, and oats, have been proved, by the most rigorous evidence, to be accidental variations of one common form, brought about no one knows how, but before our eyes, and rendered permanent by equally mysterious agency. Then, says Reason, if these inconceivable changes have been proved to occur among orchidaceous plants, why should they not also occur among grain plants? for it is not likely that such vagaries will be confined to one little group in the vegetable kingdom: it is far more rational to believe them to be a part of the general system of the creation.

And then arises the puzzling question of—where do the grain plants come from—what country gave them birth—where are they still to bo met with in their savage haunts? History says, nowhere. The origin of wheat is wholly unknown; so is that of oats. Rye is said to occur wild in some of the Caucassian provinces, but that is doubtful; and the barley which was found by Col. Chesney, in Mesopotamia, may have been the remains of cultivation. How then can we be *sure* that wheat, rye, oats and barley, are not all accidental offsets from some unsuspected species?

A gentleman who lately travelled in Germany, was assured that if oats are sown early, not allowed to produce ears for the first year, but compelled by artificial means to defer their earing to the second, they will change to other sorts of grain. A seemingly more monstrous proposition never emanated from the father of paradox. Nevertheless, there could be no harm in putting the statement to the proof. The Marquess of Bristol has done so. At his lordship's request, the Rev. Lord Arthur Hervey, in the year 1843, sowed a handful of oats, treated them in the manner recommended, by continually stopping the flowering stems, and the produce in 1844, has been for the most part, ears of a very slender barley, having much the appearance of rye, with a little wheat, and some oats; samples of which are, by favor of Lord Bristol, now before us. What is to be inferred from this?

But, it will be said, has the question been fairly tried? The mode was this: A handful of oats was taken out of a manger, sown in a garden, diligently cared for, and finally reaped. As oats do not usually consist of a mixture of barley, wheat and oats, it could not be suspected that any error would so arise, more especially since the barley that has been raised is not exactly barley, for it is longer and thinner—nor rye, for it wants the structure of that sort of grain. Nevertheless, there is the possibility of error; and therefore the experiment will be repeated with every precaution, and we hope to be allowed to report the result.

In the meanwhile, it would be as well if a good many persons would try the experiment in different parts of the country. The question is, whether, by any means wheat, oats, barley, and rye, can be made to change into each other. The Germans say it will happen if oats are sown early, and prevented flowering till the second year. Gerarde says he saw it happen to some extent, though he did not know how. Is this true or not?—*Gardeners' Chronicle.*

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*Fall Transplanting.*—Mr G. Newell, of Dorchester, says: "Persons wishing to set out trees, will find the fall much the best time, as the land is in a much better condition then than in the spring. In setting out trees in the fall, it requires a shovelfull of coarse straw manure around each tree, with a few shovels of soil on top, to prevent the heaving of the roots. Trees managed in this way, will make much larger growths the coming season than if set in the spring; the dry weather of the succeeding year will not affect them as those set out in spring. All young trees should receive the above protection for three or four years after being set out: the extra soil can be removed late in the spring of the year, leaving the manure around the trees. Experience tells me that by setting out trees in the fall, with the above precaution, I do not lose one-half the trees that I do by setting out in the spring."

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*Green Crops for Manure.*—It has been contended by some that plowing in crops in a dry or dead ripe state, is more efficacious than turning them under when green. Prof. Johnston does not agree to this. He says: "Growing plants bring up from beneath, as far as their roots extend, those substances which are useful to vegetation, and retain them in the leaves and stems. By plowing in the whole plant, we restore to the surface what had sunk to a greater or less depth, and thus make it more fertile than before the green crop was sown. This manuring is performed with the least loss by the use of vegetables in the green state. By allowing them to decay in the open air, there is a loss of organic and inorganic matter: if they be converted into fermented (farm-yard) manure, there is also a large loss—and the same is the case, if they are employed in feeding stock, with a view to their conversion into manure. In no other form can the same crop convey to the soil an equal amount of enriching matter, as in that of green leaves and stems. Where the first object, therefore, in the farmer's practice is to use his crops as to enrich his land, he will soonest effect it by plowing them in the green state."

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*The Potato.*—The discovery of America gave to the civilized world, in the potato, an acquisition of more importance than all its mines of silver and gold. The introduction of its culture may justly be considered as a new era in the annals of domestic economy. It is to the potato that Ireland owes her rapid increase in population, and enables her on a territory less than half the size of Virginia, to support more than *seven millions* of people, and produce annually a considerable surplus of provisions for exportation.



Fig 3. Front page of the *New England Farmer* featuring citation from the article of John Lindley ("Transmutation of Grain" *New England Farmer* v.23 1844: 161). Credits: Public Domain, Google-digitized.

Scandalized by the periodical's readiness to expose claims held by believers in transmutation, Townsend ridiculed Lindley's example, suggesting that "this is sufficiently ludicrous,

and let us no longer wonder that *book farming* is laughed at, when such agricultural journals […] and such men as Professor Lindley, the 'learned botanist', seriously recommend" that more experiments be made to resolve the matter.[192] Admitting that he "never saw the inside of a college, or of a professor's laboratory", Townsend stated that if he were a learned man who "felt disposed to 'astonish the natives' by announcing the discovery of some wonderful vagaries, and strange freaks of nature", he would procure and exhibit solid proof of transmutation. Instead, men of science such as Lindley would "blunder from nature's well defined paths, into the wild, theoretical, ideal road of *transmutation*". Townsend's letter generated numerous responses, among which those that recalled the 1830s peak of the transmutation debate to remind readers that its result had been "a *drawn* battle" and "it was not settled that science, as it is called, was exactly *right* in its *first* principles, although no one has a more profound respect for that authority, apparently, than both parties engaged in the controversy".[193] A different contributor remarked that "Dr. Lindley ought to be high authority, but great men are not always wise" and presented the following claim intended to conclude the debate:

> "During the long controversy on wheat turning into chess, several instances were stated by gentlemen of unimpeachable veracity, of farms and districts, where not a single stalk of chess were discovered among the wheat in many years – say 20, 30 – and even longer period. Now, one well established fact of this kind, is sufficient to overweight the testimony of a thousand Dr Lindleys, where the more careless the experimenter in favor of transmutation, the more likely he is to succeed"[194]

Outside agricultural press, Northeastern audiences were exposed to two different perspectives on nature directly related to the transmutation controversy among the American scientific community. The second round of the transmutation debate in the mid-1840s coincided

[192] "Transmutation of Grain" *Cultivator* v.1 ser.2 1844-5: 132. For a response from the periodical, see "Transmutation of Grain" *New Genesee Farmer* v.23 1845: 326.
[193] "Transmutation of Grain" *Cultivator* v.1 ser.2 1844-5: 183. For other responses, see "Transmutation" *Cultivator* v.1 ser.2 1844-5: 216; "Transmutation Controversy" *Cultivator* v.1 ser.2 1844-5: 248; "Items" *Cultivator* v.1 ser.2 1844-5: 310.
[194] "The Influence of the Barberry, and the Doctrine of Transmutation" *Cultivator* v.4 1847: 213.

with the publication of a volume on a topic which became an international sensation. Robert Chambers's anonymously published *Vestiges of the Natural History of Creation* gained immense popularity in the United States and, as James Secord remarked in his seminal study of the work's reception, it sold more copies and attracted more readers than in Britain.[195] Once the philosophical implications of *Vestiges* dawned on the scientific and theological circles, the work became subject to fervent attacks, and by 1850 had dozens of reviews and fifteen books published in its opposition.[196] Interestingly, Robert Chambers referenced that same article by John Lindley in a sequel to the *Vestiges*, where he quoted the botanist at length and located him as the authority on the subject of transmutation.[197] At the same time, the American public began to celebrate the expertise of a famous Swiss zoologist, Louis Agassiz, who had just arrived in the United States. During the winter of 1846-7, Agassiz gave a series of popular lectures on "The Plan of the Creation, Especially in the Animal Kingdom" at Boston's Lowell Institute which attracted twice as many viewers than expected by organizers.[198] Even though the lectures had not been documented, their content can be inferred from the transcript of a later series Agassiz gave in New York in the fall of 1847. Indebted to Georges Cuvier, Agassiz presented an anti-transmutationist view of species formation that would underpin his heated debate with Asa Gray on species evolution a decade later. "In the succession of the changes of an individual", Agassiz argued, "we have really a progress in one thing; but we have in the other case a progress of the plan – and a progress of a plan arising in a succession of species which do not descend from each other – which have never been derived from each other".[199]

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[195] Secord, *Victorian Sensation*, 38, 380-2. For the reception of Chambers's work among the American scientific community, see Daniels, *American Science*, 57-9; Ryan C. MacPherson, "The Vestiges of Creation and America's Pre-Darwinian Evolution Debates: Interpreting Theology and natural Sciences in Three Academic Communities" PhD dissertation, Notre Dame, Indiana, 2003.

[196] Bruce, *The Launching of Modern American Science*,123-4.

[197] Robert Chambers, *Explanations: A Sequel to the Vestiges of the Natural History of Creation*, London: John John Churchill, 1846.

[198] Edward Weeks, *The Lowells and Their Institute*, Boston: Little, Brown, and Co., 1966: 52-3.

[199] Louis Agassiz, *An Introduction to the Study of Natural History, in a Series of Lectures Delivered in the Hall of the College of Physicians and Surgeons*, *New York. Illustrated with Numerous Engravings*, New York: Greeley and McElrath, 1847: 25. For recent scholarship on Agassiz, see Christoph Irmscher, *Louis Agassiz. Creator of American Science*, Boston: Houghton Mifflin Harcourt, 2013.

The view of nature proposed by Agassiz had a great influence on American science education as his 1848 textbook *Principles of Zoology* served as classic teaching material well into the second half of the nineteenth century.[200] Readers of botany would encounter a similar vision of the natural environment in the immensely popular Asa Gray's 1836 *Elements of Botany* where the botanist argued that "[t]here can be only *one* natural system of botany, if by this term is meant the plan according to which the vegetable creation was called into being".[201] Together with Edward Hitchcock's 1851 *Religion of Geology*, Agassiz and Gray located their disciplines in a widespread narrative of nature which presented their emergent scientific professions as occupations founded on predictable patterns, rendering the study of nature relevant to the development of the national economy. The American variant of the theology of nature had enabled naturalists to provide solid ground for delineating the expertise of scientists. As the transmutation debate illustrates, the agricultural reformers used a similar strategy to construct the authority of science in the study of nature.

### 2.5 *Perils of Disorder – Transmutation and Theology of Nature*

Scholarship on the history of evolutionary ideas indicates that advances in sciences such as geology, paleontology, or embryology challenged the static view of nature that underpinned the traditional activity of naturalists; the classification of living organisms.[202] Remarking on a common belief in peach originating from wild lime, a contributor to the *Genesee Farmer* exclaimed: "Such a change would be transmutation indeed! and Botany would no longer be a science".[203] To admit the

[200] Keith R. Benson, "From Museum Research to Laboratory Research", 57.
[201] Asa Gray, *Elements of Botany*, revised edition, New York: American Book Company, 1887: 182.
[202] For history of evolutionary ideas, see Stephen Jay Gould, *The Structure of Evolutionary Theory*, Cambridge, MA: Harvard University Press, 2002; Peter J. Bowler, *Evolution. The History of an Idea*, Berkeley: University of California Press, 1989; Ernst Mayr, *The Growth of Biological Thought. Diversity, Evolution and Inheritance*. Cambridge, MA: Belknap Press of Harvard University Press, 1982. For the reception of evolution in the United States, see Ronald L. Numbers, *Darwinism Comes to America*, Cambridge, MA: Harvard University Press, 1998; Jeffries Wyman, "Philosophical Anatomy, and the Scientific Reception of Darwin in America" *Journal of the History of Biology* 21 (1988): 69-94.
[203] "Wonders of Horticulture" *New Genesee Farmer* v.2 1841: 66.

validity of species transmutation would be to question the authority of botany as a scientific discipline, but also, as many contributors believed, to "throw the beautiful order of Creation into inextricable confusion".[204] Tracing the emergence of institutionalized biological research in nineteenth-century United States, Keith Benson emphasized the role American natural theology played in providing "the vehicle to carry natural history from academic institutions to the public".[205] Andrew J. Lewis persuasively argued that the American intersection of scientific and theological beliefs about the environment had constituted a theology of nature, rather than natural theology.[206] The belief that a close study of nature could reveal patterns and laws governing God's perfectly ordered design underpinned American natural history and, as the preceding paragraph suggested, had been present in scientific education as well.[207] An example which illustrates the popularity of these tenets is the natural history museum organized by Louis Agassiz, which attracted the sum of $150,000 from private and federal donations, all allocated to "exhibit the thoughts of the Creator as manifested in the visible world", according to Agassiz's explanation.[208]

The American theology of nature and its argument for design had not been exclusive to the scientific communities, as its tenets informed the writings of agricultural reformers. In the *Farmer's Companion*, Jesse Buel drew the following vision of the American farmer, clearly based on biblical rendering of creation:

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204 "Wheat Turning Into Chess" *New Genesee Farmer* v.2 1841: 84.

205 Keith R. Benson, "From Museum Research to Laboratory Research", 56-9. See also Burnham, *How Superstition Won and Science Lost*, 144-9.

206 Lewis, *A Democracy of Facts*, Chapter 4. For scholarship on natural theology and science, see Jonathan Topham, "Science, Natural Theology, and Evangelicalism in Nineteenth-Century Scotland: Thomas Chalmers and the Evidence Controversy," in *Evangelicals and Science in Historical Perspective*, David N. Livingstone et al (eds.), New York: Oxford University Press, 1999: 142-176; John H. Brooke, *Science and Religion: Some Historical Perspectives*, New York: Cambridge University Press, 1991, Chapter 6. For the American angle, see Walter H. Conser, *God and the Natural World. Religion and Science in Antebellum America*, Columbia: University of South Carolina Press, 1993; Daniels, *American Science in the Age of Jackson*, Chapter 9; Herbert Hovenkamp, *Science and Religion in America, 1800-1860*, Philadelphia: University of Pennsylvania Press, 1978; Dwight Theodore Bozeman, *Protestants in an Age of Science: The Baconian Ideal and Antebellum American Religious Thought*, Chapel Hill: University of North Carolina Press, 1977. See also Dov Ospovat, *The Development of Darwin's Theory: Natural History, Natural Theology, and Natural Selection, 1838-1859*, Cambridge: Cambridge University Press, 1981.

207 Keith R. Benson, "From Museum Research to Laboratory Research", 59.

208 Qtd. in Pauly, *Biologists*, 36-7.

> "The elements are subservient to his use; the vegetable and animal kingdoms are subject to his control! And the natural laws which govern them all, and which exert a controlling influence upon his prosperity and happiness, are constantly developing to his mind new harmonies, new beauties, perfect order, and profound wisdom, in the works of Nature which surround him".[209]

This view of nature had been a constant point of reference during the transmutation debate. In 1856, the editors of the *Country Gentleman* still referred to the "unalterable law of the God of Nature" which supposedly regulated plant heredity.[210] The transmutationists maintained that nature is inherently mutable and that it is "constantly working wonders and producing monsters both in the animal and vegetable portions of her production".[211] They were, however, a minority. At the height of transmutation controversy in the early 1830s, the *Genesee Farmer* published a series of contributions from an author writing under the initials W. W. B., who presented extensive argumentation against the "strange and unnatural theory of transmutation".[212] "How has it come to pass, that that plant which yields to man the 'staff of life', has ceased in any instance, '*to yield seed after its kind*', but instead thereof a worthless grain scarce fit for the cattle to eat?", he lamented over the escalation of the transmutation debate.[213] In the second part of his letter, he continued the exposition of "this universal law which God has impressed upon the vegetable as well as the animal world: that one species or genus of plants shall not turn to another: and thus confutes the absurd doctrine of transmutation".[214] Therefore, as the editors of the *Cultivator* put it, "the theory of transmutation [was] in direct contradiction to the whole known order of nature".[215]

In the discussion of species transmutation, the community surrounding the agricultural press frequently referred to a "fundamental and established law of nature", according to which "it is the

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[209] Jesse Buel, *The Farmer's Companion*, 30.
[210] "Wheat Turning to Chess" *Country Gentleman* v.7 1856: 320.
[211] "Cheat Produced From Wheat" *Farmer's Register* v.2 1835: 60.
[212] W. W. B., "Wheat Which is Eaten Off in the Fall, Supposed to Turn to Chess" *Genesee Farmer* v.3 1833: 91.
[213] W. W. B., "The Authority of the Sacred Scriptures Against the Doctrine of Transmutation of Grain – No.I" *Genesee Farmer* v.3 1833: 373.
[214] W. W. B., "The Authority of the Sacred Scriptures Against the Doctrine of Transmutation of Grain – No.II" *Genesee Farmer* v.3 1833: 380-1.
[215] "'Popular Errors' Reconsidered" *Cultivator* v.7 1840: 128.

nature of plants to produce their like, or plants of the same kind", therefore "changing the nature of a plant as to turn it into another of a different kind would be equivalent to creating a new kind of plant, and giving it a specific nature distinct from any which has ever existed".[216] This opinion had been "not only supported by the inspired writings, but by the philosophy of nature".[217] During the antebellum period, the widespread discourse of the theology of nature regulated the dialog between religion and science as scientific facts were used to demonstrate the laws governing God's design. Theological contributors such as R. H. Sheldon used the authority of "experiments conducted scientifically and minutely in detail" as proof in their argumentation against species mutability.[218] Since "in all operations of nature we observe certain fixed and invariable principles which are never violated", he argued, "the laws of Nature are eternal and unchangeable" and to believe in transmutation would be to "suppose an innovation and perversion of the established laws of nature".[219] In 1838, the *Farmer's Cabinet* reprinted a vigorous anti-transmutationist piece where the contributor combined the authority of the Bible with "most extensive observations in Botanical science", arguing that if transmutation were true, "[t]he vegetable world would soon run into the wildest confusion" and agriculture "would become the most precarious of employments" as "crops might, at any time, be metamorphosed into a forest of oaks". Two years before the publication of Charles Darwin's *On the Origin of Species*, a contributor to the *Country Gentleman* offered scathing commentary on the *Vestiges*, and while allowing certain "changes in appearance or structure" that might be "transmissible to the offspring", he still referred to the laws of nature, arguing that "the mutations thus superinduced are governed by constant laws, and confined within certain limits". "Indefinite divergence from the original type", he suggested, "is not possible, and the extreme limit

[216] "An 'Old Farmer's' Opinion" *Monthly Genesee Farmer* v.2 1836-7: 21.
[217] R. H. Sheldon, "Transmutation of Grain" *Monthly Genesee Farmer* v.2 1836-7: 174-5.
[218] Ibid.
[219] Ibid.

of possible variation may usually be reached in a short period of time; in short, species have a real existence in nature, and a transformation from one to another does not exist."[220]

"Think of the hot controversies about the transmutation of species, which would have been spared", argued the same writer in an earlier contribution, "if a clear conception of the meaning of species had been steadily held before the disputants, or if the laws which regulate heritage had been duly considered".[221] "In one sense, transmutation of species is a contradiction of terms", he continued, as to "ask if one species can produce another – i.e., a cat produce a monkey – is to ask if the offspring do not inherit the organization of their parents. We know they do and cannot conceive it otherwise". Fixity of species had been essential to botanists and their systems of classification, which excluded the possibility of transmutation. Classic scholarship on the history of species locates the origin of species fixism in the writings of John Ray, a seventeenth-century naturalist and author of *Historia Plantarum Generalis*, a work where he offered the first biological definition of species as a group of organisms which shared a hereditary essence. "After long and considerable investigation, no surer criterion for determining species has occurred to me than the distinguishing features that perpetuate themselves in propagation from seed", argued Ray. He also addressed the problematic distinction between species and varieties: "Thus, no matter what variations occur in the individuals or the species, if they spring from the seed of one and the same plant, they are accidental variations and not such as to distinguish a species".[222] A similar understanding of species permeated the American natural history; in 1841, physician and botanist William Darlington criticized Featherstonhaugh's statement on species mutability, deeming it unlikely "that objects of natural history should lose the distinctive characters impressed on them by the hand of the Creator".[223]

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[220] "Transmutation of Species" *Country Gentleman* v.10 1857: 163. This piece was the last installment of a series – for other contributions from the same author under the name of Columella, see "In-and-In Breeding – No. I" *Country Gentleman* v.9 1857: 300; "In-and-In Breeding – No. II" *Country Gentleman* v.10 1857: 28.

[221] "In-and-In Breeding – No. II" *Country Gentleman* v.10 1857: 28.

[222] Quoted in Mayr, *The Growth of Biological Thought*, 256.

[223] Fragments of the lecture were reprinted in "ART. XIII. – Bibliographical Notice" *The American Journal of Science* v.41 1841: 365-9.

"I verily believe that man can change nothing that God has made. He may modify, but cannot change. Now, I believe that he has impressed on wheat, oat, and flax seed unalterable propensities, which cannot be altered by man", argued one reader.[224] His argument could be easily extended to other plant and animal species, popularly conceptualized as created by God each after its own kind. This tenet found confirmation in the sterility of hybrids, proving that hybridization, also called "muling", had been similarly to transmutation "a violation of nature's law, by which the races as distinct species are governed".[225] "The difficulty of muling, and the inability of hybrids to perpetuate their race", argued the editors of the *Cultivator*, "appears to be the result of a wise law of nature, intended to preserve the identity of races, and prevent the universal mixing and confusion which would otherwise have resulted from a confounding or loss of individual species".[226] Even if rare, hybrids illustrated the fluid character of species identity. Thus, they were regarded as artificially produced "amalgamations" of traits belonging to different organisms, considered "strange and unnatural mixtures of species", or dismissed as mere varieties "possessed of permanent characters […] accidentally produced by seed".[227] Problematizing the distinctive nature of species identities, hybridizing found opposition among audiences located on the other side of the Atlantic as well. In 1881, the editors of the *Gardeners' Chronicle* recounted how "[h]ybridising was formerly regarded as a sacrilegious subversion of nature, and those who practiced the art were stigmatized as mischievous intermeddlers in the works of the Creator".[228] Foregrounding the question of origin of chess, the transmutation debate directly referred to the problem of species fixity. A contributor to the Country Gentleman argued:

"The science of Natural History is founded on the existence and permanence of distinct

[224] "Transmutation of Grain" *Genesee Farmer* v.4 1834: 15.
[225] "Hybrids" *Cultivator* v.9 1842: 47.
[226] "Mule" *Cultivator* v.10 1843: 191.
[227] E. Hull, "Hybrid Melons" *Genesee Farmer* v.5 1835: 396-7; W. W. B., "The Authority of the Sacred Scriptures Against the Doctrine of Transmutation of Grain – No.I" *Genesee Farmer* v.3 1833: 373; "Short Letters of Botany" *Country Gentleman* v.7 1856: 81-2.
[228] *Gardeners' Chronicle* v.15 1881: 48.

> species, each possessing individual characteristics, rendering it dissimilar to every other. The whole theory and practice of gardening, farming, and stock breeding is based on this invariable law, that 'like produces like', in both the vegetable and animal kingdom'".[229]

The concept of species mutability had been thus incompatible with the authoritative theological narrative of nature which represented the environment as a static order. This view had been entertained by the emergent professional community of American naturalists as well as agricultural reformers. Both groups contributed to the prevalent representation of species transmutation as "unnatural", thereby formulating a discourse that would resurface in public reactions to scientific breeding and genetic modification strategies during the following century.

## 2.6 *Conclusion*

The transmutation debate which unfolded on the pages of Northeastern agricultural periodicals between 1820 and 1859 offered an opportunity to the community of agricultural reformers – composed of editors, contributors, and readers – for accommodating elements of botanical knowledge in the public sphere. Emphasizing the value of botany to agriculture as a field of knowledge that could potentially provide farmers with theoretical principles governing plant heredity, the agricultural press frequently shared contributions which communicated knowledge about species and varieties in the hope of convincing practical farmers that transmutation was nothing else than a persistent superstition. Editors of the agricultural press had been aware of the common prejudice against "book farming", and thus chose to embed the problem of species transmutation in a methodological framework present in the American agricultural tradition. Even though botanists themselves did not engage in such activities at the time, the reformers utilized the tradition of experimentation to grant the discipline of botany the authority over the study of nature. Editors frequently provided instructions for inducing transmutation, and thus promoted an

[229] "Transmutation of Species" *Country Gentleman* v.10 1857: 163.

interventionist experimentation model which would become regarded as a legitimate method for studying organisms only during the second half of the nineteenth century. The experimental paradigm gained strength in the American biology during the last quarter of the century when major figures connected to the Johns Hopkins University, among them Thomas Hunt Morgan, proclaimed the value of combining traditional descriptive studies with experimental investigation to render the discipline of biology more "scientific".[230] In his 1903 volume, *Evolution and Adaptation*, Morgan praised Hugo de Vries's experimental work on plant mutations precisely because, in contrary to the Darwinian mechanism of natural selection, it provided biologists with a testable and productive working hypothesis to explain the evolutionary process.[231]

Calling for proofs of transmutation on the pages of agricultural periodicals, the nineteenth-century reformers articulated particular expectations about "scientifically" produced knowledge that had been shared among the reformist community. Which criteria should an experiment meet to be considered scientific and its results valid? Who had the authority to speak about nature? In their coverage of the transmutation debate, agricultural periodicals delineated the answers to these questions, thereby contributing to the shaping of the methodological rules of scientific inquiry as science underwent professionalization. Negotiating the public authority of science, the reformist community firmly positioned botanists as authoritative figures in the study of nature, convinced that "[n]o botanist who is deserving of the name, and who has studied Vegetable Physiology to any advantage, can ever admit the possibility of one genus changing into another".[232] Given the precarious state of American biology which throughout the nineteenth century allowed very few

[230] In his classic biography of Thomas Hunt Morgan, Garland E. Allen positioned the scientist opposing the dominating tradition of descriptive morphology in favor of a mechanistic and experimental outlook on biology, see Garland E. Allen, *Thomas Hunt Morgan: The Man and His Science*, Princeton: Princeton University Press, 1978; ibid, "T. H. Morgan and the Emergence of a New American Biology" *The Quarterly Review of Biology* 44.2 (1969): 168-88. Jane Maienschein persuasively argued that the key figures in the development of American biology such as Edmund Beecher Wilson, Edwin Grant Conklin, or Thomas Hunt Morgan, did not altogether reject the descriptive approach which dominated the discipline, see Jane Maienschein, *Transforming Traditions in American Biology, 1880-1915*, Baltimore: Johns Hopkins University Press, 1991: 234-5; 249-50.

[231] Thomas Hunt Morgan, *Evolution and Adaptation*, New York: Macmillan, 1908 [1903]: 297-9.

[232] "Cheat or Chess" *Monthly Genesee Farmer* v.1 1836-7: 85-6.

scientists to find stable employment, the certainty with which these editors granted authority to science is remarkable. Plant systematics which underpinned botany constructed the discipline's authority through an emphasis on the collection of scientific facts and production of systematic knowledge founded on universal laws and principles. During the transmutation debate, this ideal clashed with non-expert knowledge founded on practical experience of farmers. What had begun as a clear opposition between "book farming" and field experience, or scientific knowledge and agricultural tradition, with time began dissolve as learned men leaned towards evolutionary explanations of species generation. During the first half of the nineteenth century, the widespread call for testing the theory of transmutation and collecting scientific facts about plant heredity generated a lively response from the community, providing the American audiences with an outlet for discussing evolutionary ideas which had been rejected by the scientific community. Even if transmutation had been incompatible with the authoritative narrative of nature formulated under the influence of the American natural theology, the agricultural press encouraged the debate, convinced that enough proof against transmutation would eradicate the belief among practical farmers and prompt them to join the Northeastern project of agricultural improvement.

Shaped by the widespread theological outlook on nature, the understanding of species as fixed entities had been prevalent among the reformist community, as it had been among the majority of the antebellum naturalists. The belief in nature as order provoked agricultural editors and contributors to locate processes such as species transmutation and generation, or species mixing, as "unnatural" and in clear violation of natural laws. "If we can doubt the presence of the pre-existing germ, where a plant of cheat springs up", argued one contributor, "we may entertain the same doubts respecting every other being, of whatever kind".[233] He continued: "The same fortuitous chance which could produce a plant, could also produce a man, without the necessity of recurring a 'Great First Cause'. And, if plants and animals can thus spring up, spontaneously, from nothing, so

[233] "Is Wheat Convertible Into Cheat?" *Farmer's Cabinet* v.2 1838: 322-4.

can all the innumerous worlds, which people the infinity of space – an idea too revolting for any serious and contemplative mind to entertain for a moment". As the following chapters demonstrate, the American press would frame the ideas of species mutability in a discourse marked by a similar tone of revulsion well into the twentieth century.

*Appendix 2.1*

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## Chapter 3

## Scientific Nature Faking: Public Discourses of Hugo de Vries's Mutation Theory in California, 1900-1914

### 3.1 *Introduction*

"Amid the bandying back and forth of phrases, the ping-ponging of accusations of misrepresentation […] sight has been lost on the greatest of all the twisters of things natural into strange and grotesque form".[234] Such sensationalized description of experimental research into plant and animal heredity appeared on the pages of the *Salt Lake Tribune* at the time of the so-called "nature fakers" controversy.[235] The heated literary debate which unfolded in 1907 between the proponents and opponents of sentimental representations of nature, the latter group notably represented by President Theodore Roosevelt, popularized the term "nature faking" to convey unrealistic depictions of nature in popular literature. The author of the article argued that the nature fakers debate had blinded the American public to the "eminent scientists [who] have been earnestly faking, not mere words, but live things", producing "strange animals" and "queer plants that grow not as did the parent on one side or the other, but in the form of an original hybrid".[236] As the present chapter illustrates, similar type of discourse permeated press representations of scientific breeding following the public emergence of an evolutionary theory formulated by the Dutch botanist Hugo de Vries, which – as classic scholarship in the history of evolution indicates – became a scientific sensation in Europe and the United States.[237]

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[234] F. B. Morse, "Uncle Sam's Official Nature Fakers" *Salt Lake Tribune* (27 Oct 1907): 6, 10. No additional information could be found about the author of the feature, likely using a pseudonym inspired by the inventor Samuel F. B. Morse.

[235] The nature fakers debate is examined in: Ralph L. Lutts, *The Nature Fakers: Wildlife, Science and Sentiment*, Charlottesville: University of Virginia Press, 2001.

[236] Morse, "Uncle Sam's Official Nature Fakers", 6.

[237] Peter J. Bowler, *Evolution. The History of an Idea*, Berkeley: University of California Press, 1989, revised edition, 276-8. For the reception of the mutation theory in Europe and the United States, see Garland E. Allen, "Hugo de

Considered as one of the "re-discoverers" of the Mendelian laws, Hugo de Vries was born in 1848 as the eldest son to a prominent family in Haarlem, Netherlands.[238] His maternal grandfather was Caspar Reuvens, a renowned professor of archaeology at Leiden University where, to the dismay of his family, de Vries chose to study natural philosophy and majored in botany. During the course of his studies, he had come into contact with experimental plant physiology practiced in Germany where de Vries pursued this direction throughout the 1870s, spending his summer holidays in the laboratory of Julius von Sachs in Würzburg.[239] Simultaneously, he had been exposed to Charles Darwin's theory of evolution by natural selection through a German translation of *On the Origins of Species*. The topic evidently captured the botanist's interest since he included elements of Darwin's theory in his doctoral dissertation which examined a physiological topic.[240] By the mid-1880s, de Vries had severed his ties with physiology and began to work on the problem of heredity and variation in earnest, applying the experimental methodology acquired during previous training to conduct plant breeding experiments at the University of Amsterdam's Hortus Botanicus.[241]

In 1889, de Vries published *Intracellulare Pangenesis*, a poorly received volume in which he gave the account of his pangenesis theory, positing the existence of tiny hereditary particles called *pangenes*, differentiated from Darwin's *gemmules*, which regulated particular features of an organism by appearing in either active or latent state. During the following decade, de Vries

Vries and the Reception of the 'Mutation Theory'" *Journal of the History of Biology* 2.1 (1969): 55-87; Peter J. Bowler, "Hugo de Vries and Thomas Hunt Morgan: The Mutation Theory and the Spirit of Darwinism" *Annals of Science* 35.1 (1978): 55-73; Jim Endersby, *A Guinea Pig's History of Biology*, Cambridge: Harvard University Press, 2007: 155-169.

238 A small number of biographical sources on Hugo de Vries is available in English, see Bert Theunissen, "Knowledge is Power: Hugo de Vries on Science, Heredity and Social Progress" *British Journal for the History of Science* 27 (1994): 291-311; Peter W. van de Pas, "Vries, Hugo De," in *Complete Dictionary of Scientific Biography*, Charles C. Gillespie (ed.), New York: Scribner, 1970-, 14: 95-105; ibid, "The Correspondence of Hugo de Vries and Charles Darwin" *Janus* 57 (1970): 173-213. A recent biography is available in Dutch, see Erik Zevenhuizen, *Vast in het spoorvan Darwin. Biografie van Hugo de Vries*, Amsterdam: Atlas, 2008. My biographical source is Erik Zevenhuizen, Introduction to Hugo de Vries, *O, Wies! 't Is hier zo mooi!*, Amsterdam: Atlas, 1998.

239 For a detailed account of de Vries's work at von Sachs's laboratory, see Peter W. Van der Pas, "The Correspondence of Hugo de Vries and Charles Darwin".

240 Ibid, 175.

241 Four sources examining de Vries's turn to the discipline of heredity, see Theunissen, "Knowledge is Power", 291-311; Ida H. Stamhuis, Onno G. Meijer, Erik Zevenhuizen, "Hugo de Vries on Heredity, 1889-1903: Statistics, Mendelian Laws, Pangenes, Mutations" *Isis* 90.2 (Jun 1999): 238-67. De Vries described it in "The Origin of the Mutation Theory" *The Monist* 27.3 (Jul 1917): 403-10.

directed his attention to a peculiar plant he collected during summer holidays at Hilversum. It was a variety belonging to the genus of the evening primrose, *Oenothera lamarckiana*, which, as De Vries had noted, appeared in different forms which when reproduced would not return to the parent type. Following almost fifteen years of breeding experiments with the evening primrose, in the fall of 1901 de Vries published the first volume of *Die Mutationstheorie* which combined his pangenesis model with insights derived from experiments to produce the theory of mutation.[242] According to de Vries, new species could arise within the period of one generation through an internal discontinuous jump or "saltation" which occurred in the hereditary material passed from parent plants to their offspring as long as they happened to undergo a "mutative period". For the botanist, mutation constituted a process of speciation which generated "elementary species" characterized by sharp distinctions from their parent types. It is telling that de Vries gave different names to his *Oenothera* mutations, distinguishing between the giant type (*Oenothera gigas*), the dwarf type (*O. nanella*), a type bearing pale leaves (*O. albida*) or red ones (*O. rubrinervis*).[243] Ernst Mayr suggests that de Vries found being anticipated by Gregor Mendel disappointing and thus avoided discussing the theoretical implications of the Mendelian segregation as his attention "shifted instead to the evolutionary interpretation of progressive mutations".[244] De Vries was convinced that *Oenothera* exemplified a tendency present in other organisms. In an article for the *Scientific American*, he expressed that conviction by stating that mutations "must occur elsewhere, too, and these must be sought".[245] However, the organisms that the botanist believed to be new species of the *Oenothera* genus were subsequently exposed as hybrids resulting from the plant's chromosomal polyploidy.[246]

By his arrival on the American shore in the spring of 1904, de Vries had already become internationally famous and recognized in his home country as a foremost scientist in plant

[242] Zevenhuizen, Introduction to *O, Wies! 't Is hier zo mooi!*, 15-8.
[243] Ibid, 16.
[244] Ernst Mayr, *The Growth of Biological Thought: Diversity, Evolution, and Inheritance*, Cambridge, MA: Belknap Press, 1982: 729.
[245] Hugo de Vries, "Experimental Evolution" *The Scientific American* 44.8 (24 Feb 1906): 167.
[246] Van de Pas, "Vries, Hugo De", 101.

physiology and the emergent field of genetics. De Vries intended to conquer not only American scientific circles but the entire nation. Between 1904 and 1912, the botanist journeyed to the United States three times and with the help of the American scientific communities, he delivered numerous public lectures, published two books intended for the lay audiences, and contributed articles to professional, as well as general-interest periodicals. Local newspapers dutifully reported de Vries's American itinerary, noting meetings with famous scientists and participation in events which shaped the history of American life sciences, especially the emergent discipline of genetics.[247] De Vries's theory gained a number of dedicated followers in public and private institutions scattered across the United States. The American followers of de Vries employed the mutation theory in constructing their disciplinary authority, promoting it a source of experimental methodology that could be productively applied to agriculture. In this, they reflected a general tendency of early geneticists to emphasize the practical implications of their discipline in search for institutional support.[248] This interest resonated with the American editors who eagerly introduced the emergent field of experimental evolutionary biology through the lens of the Progressive and entrepreneurial view of pure scientific research. De Vries encouraged the production of artificial mutations and inspired a wide range of breeding experiments conducted by American botanists such as Daniel T. MacDougal, Albert F. Blakeslee, Charles S. Gager, or George H. Shull, who would all transition into the field of plant genetics.

Despite the immense scale of *Oenothera* experiments conducted on the East Coast at the New York Botanical Garden and the Station for Experimental Evolution in Cold Spring Harbor, it

[247] De Vries was present at the opening of the the Station for Experimental Evolution in Cold Spring Harbor in 1904, and the Rice Institute in Houston, Texas, in 1912.

[248] Barbara Kimmelman, "Mr. Blakeslee Builds His Dream House: Agricultural Institutions, Genetics, and Careers 1900-1915" *Journal of the History of Biology* 39 (2006): 241-280; Toby Appel, "Organizing Biology: The American Society of Naturalists and Its 'Affiliated Societies', 1883-1923" in *The American Development of Biology*, R. Rainger, Keith R. Benson and Jane Maineschein (eds.), Philadelphia: University of Pennsylvania Press, 1988: 87-120; Barbara Kimmelman "A Progressive Era Discipline. Genetics at American Agricultural Colleges and Experiment Stations, 1900-1920" PhD dissertation, University of Pennsylvania, 1987; ibid, "The American Breeders' Association: Genetics and Eugenics in an Agricultural Context, 1903-13" *Social Studies of Science* 13.2 (1983): 163-204.

was the Californian audiences who were best equipped to imagine the practical applications of de Vries's theory of mutation. Mythologized as the American Eden and the culminating point of the nation's westward expansion, the turn-of-the-century California offered a particular context for accommodating scientific knowledge about plant heredity and biological mutation in the public sphere. The intersection of agricultural profit and modification of inherited traits had been already established in the celebration of the renowned Californian horticulturist, Luther Burbank. Once de Vries reached California in 1904, the press began to conceptualize the botanist's mutation research as a theoretical counterpart of Burbank's practical achievements, continuously suggesting that the theory promised a similar economic value, even if no profitable mutations ever materialized. De Vries capitalized on this relation in his popularizations, aligning *Oenothera* research and other experimental evolutionary theories with the productive techniques of plant hybridization. Consequently, the Californian newspaper editors who represented the growing entanglement of scientific knowledge and farming – in the context of the widespread shift in the American agricultural practice – frequently chose to associate the practice of scientific breeding with the quality of artificiality. The feature quoted at the beginning of this chapter serves as the most explicit example of this tendency by referring to products of experimental heredity research as “nature fakes”, and scientists involved in breeding experiments as “nature fakers”. The turn-of-the-century discourse of hereditary modification reflected, as we shall see, the degree to which scientific breeding had been incompatible with the authoritative narratives of nature circulating in the American society – in particular, with the vision of nature conveyed in the influential writings of John Muir, a prominent environmentalist who since the Gilded Age inspired the national trend in nature-appreciation. Elevating the status of the Californian wilderness, Muir constructed a spiritual vision of nature untouched by human civilization that would later serve as the foundation for the Californian preservation movement.

## 3.2 *Popularizing Mutations in the Early Twentieth Century*

De Vries's insistence on popularizing the mutation theory must have seemed rather unusual to American scientists discouraged by yellow journalism and its unsatiated hunger for sensational representations of science. At the dawn of the twentieth century, American science was conducted in private environments. Scientists who worked for industrial or university employers did not need to build a public image for their disciplines. Consequently, the decades between 1890 and 1910 offered a relatively small volume of quality science popularization in popular newspapers and general-interest magazines. The breakthrough came with the First World War which brought a wave of changes in the organization and funding of scientific research, with the federal sector growing in importance and urging scientific communities to conduct public outreach campaigns to position science as a factor in the national industrial productivity.[249] The expositions of de Vries's theory in the American press in many respects signaled the future direction of American science popularization which would promote the positivistic ideology of science.[250]

The chapter examines features and articles printed in local American newspapers between 1900 and 1914, with a focus on three largest daily newspapers published in the San Francisco Bay Area; the *San Francisco Examiner*, *San Francisco Chronicle*, and *San Francisco Call* (Figure 4). Staunchly Republican, the *San Francisco Chronicle* was established in 1865 by teenage de Young brothers and quickly rose to prominence with coverage of scandals and political attacks. It competed for readership with the *San Francisco Examiner* which boasted the highest circulation in the Bay Area. The newspaper was founded following Abraham Lincoln's assassination on what

[249] For scholarship on science popularization in early twentieth-century America, see Marcel C. LaFollette, *Making Science Our Own. Public Images of Science 1910-1950*, Chicago: University of Chicago Press, 1990; John C. Burnham, *How Superstition Won and Science Lost. Popularizing Science and Health in the United States*, New Brunswick: Rutgers University Press, 1987; Ronald C. Tobey, *The American Ideology of National Science, 1919-1930*, Pittsburgh: University of Pittsburgh Press, 1971.

[250] Burnham, *How Superstition Won and Science Lost*, 127.

remained from the pro-slavery Democratic Press and transformed into the *Examiner* by George Hearst who had purchased the paper in 1880. Once transferred to his son, William Randolph Hearst, the newspaper flourished under the editorship of the most recognized names in the American publishing, as well as correspondents who dispatched sensational news from every corner of the world. The *San Francisco Call* was another conservative and Republican daily newspaper, at the time owned by a noted Californian industrialist and philanthropist, John D. Spreckels. By 1906, the *Call* started to lose ground in the circulation war with other papers and seven years later it was merged with the *Evening Post* by William Randolph Hearst.[251] Fueled by the cultural climate of the Progressive Era, the managing editors of these and other daily newspapers appealed to audiences interested in self-improvement by presenting practical and often sensationalized applications of scientific knowledge.[252] As the present chapter indicates, the coverage of de Vries's mutation theory followed this tendency which is striking when contrasted with representations offered in the British press that predominantly focused on the theoretical implications of the mutation theory.[253]

| Title | 1902 | 1904 | 1906 | 1908 | 1910 | 1912 | 1914 |
|---|---|---|---|---|---|---|---|
| *San Francisco Examiner* (morning) | 85.984 | 108.792 | 98.870 | 97.750 | 103.663 | 116.290 | 107.120 |
| *San Francisco Examiner* (Sunday) | 109.432 | 144.260 | 148.822 | 169.900 | 175.000 | 190.250 | 205.109 |
| *San Francisco Chronicle* (morning) | 79.667 | 93.569 | 93.569 | 50.000 | 50.000 | 70.000 | 66.087 |
| *San Francisco Chronicle* (Sunday) | 91.000 | 93.569 | 93.569 | 70.000 | 70.000 | 85.000 | 78.411 |
| *San Francisco Call* (morning) | 55.068 | 60.940 | 62.824 | 50.000 | 60.960 | 62.428 | - |
| *San Francisco Call* (Sunday) | 59.500 | 80.984 | 88.643 | 60.000 | 68.000 | 73.645 | - |

Fig 4. Circulation of the *San Francisco Examiner*, *San Francisco Chronicle*, and *San Francisco Call*, morning and Sunday editions, between 1902 and 1914. Source: *American Newspaper Annual and Directory*, Philadelphia: N. W. Ayer and Sons, 1902-14.

[251] See Workers of the Writers' Program of the Work Projects: Administration in Northern California, *San Francisco. The Bay and Its Cities*. New York: Hastings House, 1940: 152-5; James David Heart, *A Companion to California*, Berkeley: University of California Press, 1987: 440-1.

[252] See Burnham, *How Superstition Won and Science Lost*, 34-7, 173, 206. Similar audiences were present in early twentieth-century England, see Peter J. Bowler, *Science for All. The Popularization of Science in Early Twentieth-Century Britain*, Chicago: University of Chicago Press, 2009: 8-13.

[253] For examples of British coverage of the mutation theory, see "Evolution by Explosion" *Edinburgh Evening News* (26 Mar 1902): 2; J. L. M., "Luther Burbank's Achievements in Plant-Breeding" *Scotsman* (27 Jun 1906): 9; "Evolution" *Hastings and St. Leonards Observer* (30 Mar 1907): 3; Henry J. Butler, "Heredity and Natural Selection" *Evening Telegraph and Post* (11 Jun 1907): 6.

Setting out on his first journey to the United States, de Vries had already possessed experience in popularization and aimed to promote his theory among the American scientific circles, as well as the lay public.[254] He frequently contributed to general-interest magazines such as the *Harper's Magazine* or *Century Illustrated Monthly Magazine*, as well as professional publications, for instance, *Science*, the *Scientific American*, and the *Popular Science Monthly*.[255] Despite limited access to such publications, the American audiences found numerous opportunities to engage with their content through short reports and summaries printed in local newspapers and magazines. For example, a section of de Vries's article published in the February 1906 edition of the *Scientific American* was partially reprinted three months later in a local Vermont newspaper, the *Spirit of the Age*.[256] Another piece contributed by the botanist to the *Popular Science Monthly* was summarized just a few days after its publication in the *Arizona Republican*, the *Albuquerque Evening Citizen*, and the *Salt Lake Tribune*. Three years later, a quotation from that same article appeared in the *Pacific Rural Press*.[257]

The first reference to de Vries's mutation theory in print appeared in a publication devoted to science popularization. In March 1901, the *Popular Science News* featured a note about de Vries's *Oenothera* experiments, only to follow it in October with another short article informing the readers how the Dutch botanist had "been the first investigator to watch the formation and development of

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254 De Vries's experience as a science popularizer is examined in Bert Theunissen, "Knowledge is Power".

255 See Hugo de Vries, "My Primrose Experiments" *Independent* (25 Sep 1902): 2285; ibid, "A New Conception Concerning the Origin of Species" *Harper's Monthly Magazine* (Dec 1904): 209-13; ibid, "Luther Burbank's Ideas on Scientific Horticulture" *Century Illustrated Monthly Magazine* 73.5 (Mar 1907): 674-81; ibid, "Experimental Evolution" *Scientific American* 61 (24 Feb 1906): 252-58; ibid,"A Visit to Luther Burbank" *Popular Science Monthly* 67 (Aug 1905): 329-47.

256 Hugo de Vries, "Experimental Evolution", reprinted in: "Evolution. Trying to Develop New Peculiarities" *Spirit of the Age* (5 May 1906): 4.

257 Hugo de Vries, "A Visit to Luther Burbank", reprinted in: "Burbank's Great Work" *Arizona Republican* (31 Jul 1905): 2; "Luther Burbank's Methods of Working the Vegetable Wonder" *Albuquerque Evening Citizen* (4 Aug 1905): 4; "The Magazines" *Salt Lake Tribune* (6 Aug 1905):6; Albert F. Etter, "Building New Types of Strawberries in Ettersburg" *Pacific Rural Press* (22 Aug 1908): 117.

new species".[258] Early press coverage in local newspapers captured de Vries's breeding experiments in a similar vein throughout the second half of 1901, often featuring an authoritative quotation from *Nature*.[259] By the mid-1902, the news about the mutation theory found its way onto the first page of the prestigious *Science* magazine in a translation of the botanist's address bearing a decidedly sensational title: "The Origin of Species by Mutation".[260] Around 1900, naturalists interested in plant and animal heredity found the gradualist hypothesis depicting the evolutionary process as based on the accumulation of minute variations regulated by the mechanism of natural selection insufficient to explain the generation of new species and varieties.[261] As put by a prominent American mutationist: "Natural selection may explain the survival of the fittest, but it cannot explain the arrival of the fittest".[262]

The problematic status of Charles Darwin's mechanism of natural selection had repeatedly been communicated to the American audiences before de Vries's mutations made their first headlines. The *Los Angeles Times* "Answers by Expert" section offers an indication of the public engagement with the topic. Between October 1902 and January 1903 editors devoted the section to the problem of natural selection in a total of six times. In December alone, questions regarding natural selection appeared three weeks in a row.[263] Amid the uncertainty enveloping the origin of plant and animals species, the mutation theory seemed to prove that species generation may occur

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[258] "A Sudden Development of Species" *Popular Science News* 35.3 (Mar 1901): 65; "Origin of Plant Species" *Popular Science News* 35.10 (Oct 1901): 237. For a similar assessment of the early coverage of de Vries's mutation theory in American press, see Jim Endersby, "Mutant Utopias: Evening Primroses and Imagined Futures in Early Twentieth-Century America" *Isis* 104.3 (September 2013): 471-503; 477.

[259] "The Origin of Species" *Iowa State Bystender* (30 Aug 1901): 3; "The Origin of Species" *Pacific Commercial Advertiser Honolulu* (6 Sep 1901): 3; "The Origin of Species" *Sunday Gazetteer* (15 Sep 1901): 1; "The Origin of Species" *Cook County Herald* (5 Oct 1901): 2. The fragment quoted from *Nature* is J. P. K., "Recent Scientific Work in Holland" *Nature* 64.1652 (27 Jun 1901): 208-10.

[260] *Science*, 15.384 (May 1902): 721-729.

[261] For a contemporary source on the status of the evolutionary theory, see Vernon L. Kellogg, *Darwinism To-Day. A Discussion of Present-Day Scientific Criticism of the Darwinian Selection Theories, Together with a Brief Account of the Principal Other Proposed Auxiliary and Alternative Theories of Species-Forming*, New York: Henry Holt, 1907.

[262] J. Arthur Harris, quoted in: Hugo de Vries, *Species and Varieties. Their Origin by Mutation*, Daniel Trembly MacDougal (ed.), Chicago: The Open Court, 1905: 825-26.

[263] "The Times' Answers by Experts" *Los Angeles Times*, editions of October 20, November 12, December 3, 10, 17, and January 14 (page 3).

suddenly – and idea which quickly found its way to the press. A contributor to the *Washington Times* offered a sensationalized interpretation of mutations which he described as springing forward "in a leopard-like leap, without regard to environment, adaptations, degenerations, use and disuse or any struggle for existence".[264] In the initial period of the theory's popularity in the United States, the American press focused on the theoretical implications of de Vries's *Oenothera* experiments, especially in the wake of the controversial lecture the botanist gave at the 1904 International Congress of Arts and Science in St. Louis. The *San Francisco Chronicle* dedicated the first page of its Friday edition to a large feature discussing de Vries's shocking statements about the origin of species. As expected, local newspapers followed suit.[265] Additionally fueled by its association with the sensational element of radium,[266] the mutation theory became a common metaphor, used with equal enthusiasm by Theodore Roosevelt in a lecture on biological analogies in history, and the editor of *Montana News* who represented Russia's decision to allow women the right to vote as a sudden mutation in the country's slow evolution.[267] In his study of the circulation of de Vries's mutation in the American culture, Jörg T. Richter showed that the concept reverberated among the contemporary humanities scholars as well.[268]

As indicated by now classic scholarship in the history of biology, the mutation theory appealed to naturalists because it offered an innovative experimental approach to studying

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[264] Leonard Keene Hirshberg, "How Some 'Mutations' Question Darwin's Theory of Natural Selection" *Washington Times* (26 Aug 1915): 8.

[265] J. Theo Wilson, "Evolution's Worst Knock" *San Francisco Chronicle* (2 Oct 1904): 3. For examples of press coverage, see: "Darwin's Theories Assailed by Scientists' Congress" *St. Louis Republic* (22 Sep 1904): 1; "Attacks Darwin Theory" *Barbour County Index* (26 Oct 1904): 3; "Attacks Darwin" *Topeka State Journal* (22 Sep 1904): 5; "Striking New Theory of Man's Origin Propounded by a Holland Scientist" *Washington Times* (9 Oct 1904): 6. The public assertion made by David Starr Jordan, president of Stanford University and recognized ichthyologist, that the controversy had been generated due to careless reporting did not impact popular representations of this newsworthy topic, see "Denies that De Vries Disagrees with Darwin" *The San Francisco Call* (7 Oct 1904): 6.

[266] Luis Campos examines the intersection of radioactivity and mutation experiments in *Radium and the Secret of Life*, Chicago: University of Chicago Press, 2015, Chapter 3. For cultural reception of radium, see Matthew Lavine, *The First Atomic Age: Scientists, Radiations, and the American Public, 1895-1945*, New York: Palgrave Macmillan, 2013.

[267] "Ex-President Roosevelt's Lecture at Oxford" *Christian Science Monitor* (7 Jun 1910): 7; "The Woman Vote in Russia" *Montana News* (14 Jun 1906): 3.

[268] Jörg T. Richter, "The Fate of Mutation: Shift, Spread, and Disjunction in a Conceptual Trajectory" *Contributions to the History of Concepts* 6.2 (2011): 85-104; 93-4.

evolution, and was in line with Lord Kelvin's estimated, shortened age of the Earth, consequently bringing botanical research to the forefront of the evolutionary debate at the dawn of the twentieth century.[269] The experimental methodology proposed by de Vries was warmly received among the American scientific circles, and quickly found its way to public communications.[270] Awaiting the arrival of de Vries in California, the editor of *The San Francisco Call* offered an enthusiastic account of the botanist's achievement:

> Scientists since Darwin have been able to do little more than pile up accumulations of lifeless facts. De Vries by a single stroke of genius has vivified this great mass and put new meaning into the theory of evolution. He has accomplished what most Darwinians believed impossible. He has shown that evolution may be observed and experimented with in the same manner as any other life process. Henceforth evolution is removed from the limits of indirect observation and speculation.[271]

American mutationists promoted de Vries's experimental methodology in professional communications with other scientists, as well as general audiences.[272] The latter interest is exemplified by the publication of two volumes based on de Vries's summer lectures at the University of California, Berkeley, given in the summers of 1904 and 1906. The first work, *Species and Varieties*, was edited by the leading American mutationist, Daniel T. MacDougal, whose intention of presenting de Vries as an exemplary experimental biologist – even though the botanist hardly exemplified the type[273] – was captured in the motto of the volume:

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[269] For classic scholarship on the history of life sciences at the dawn of the twentieth century, see Peter J. Bowler, *The Mendelian Revolution: The Emergence of Hereditarian Concepts in Modern Science and Society*, Baltimore: Johns Hopkins University Press, 1998, ibid, *The Eclipse of Darwinism: Anti-Darwinian Evolution Theories in the Decades Around 1900*, Baltimore: Johns Hopkins University Press, 1992; ibid, *Evolution*, *C*hapter 9; Ernst Mayr, *The Growth of Biological Thought. Diversity, Evolution and Inheritance*. Cambridge, MA: Belknap Press of Harvard University Press, 1982, Chapter 12.

[270] See Hollis Godfrey, "A Biological Sequence" *Boston Evening Transcript* (3 Feb 1906): 2.

[271] "Many Attending Summer Session" *San Francisco Call* (27 Jun 1906): 4.

[272] See Daniel T. MacDougal, "Discontinuous Variation and the Origin of Species" *Science* 21.535 (7 Apr 1905): 540; ibid, "Hugo de Vries" *Open Court* 19.8 (1905): 449-453; Henri Hus, "Hugo de Vries" *Open Court* 20.12 (1906): 713-25; J. Arthur Harris, "A New Theory on the Origin of Species" *Open Court* 4.1 (1904): 18.

[273] For a brief examination of de Vries's experimental approach, see: Stephen Jay Gould, *The Structure of Evolutionary Theory*, Cambridge, MA: Harvard University Press, 2002: 420-1.

*The origin of species is a natural phenomenon.*/Lamarck.
*The origin of species is an object of inquiry.*/Darwin.
*The origin of species is an object of experimental investigation.*/De Vries.[274]

These three statements conveyed a simplistic history of the evolutionary thought, situating de Vries's experimental methodology as its most recent and valuable iteration. The volume was widely reviewed in the American press and reprinted soon after its publication. Before the end of the decade, it was translated into Italian, German, French, and Dutch.[275] Represented in this form, the mutation theory offered a remarkably democratic take on evolutionary science, suggesting that a wider audience could be potentially incorporated into the collection of data about plant mutations. The problem of species generation had become, to quote MacDougal, "so simplified that any one [sic] with a small garden at his command may, with patience, hope to make some substantial contribution to the subject".[276] Elsewhere, he stated the de Vries's theory offered "methods so simple that they may be followed by naturalists with only elementary training".[277] The second volume of de Vries's Berkeley lectures, *Plant Breeding*, offered a similarly accessible account of scientific breeding, described by the *Evening Star's* reviewer as a "scientific book in simple language of special value to botanists, horticulturists and farmers".[278] A British reviewer of the volume stated that it "can be confidently commended to the notice of the practical plant-breeder as well as to students of science", accurately reflecting de Vries's priorities in presenting his theory to the American public.[279]

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[274] Hugo de Vries, *Species and Varieties*, v.

[275] Translations of the book were reviewed by J. Arthur Harris, "The Reception of the Mutation Theory" *American Naturalist* 41.483 (Mar 1907): 189-190; George H. Shull,"De Vries's Species and Varieties" *American Naturalist* 43.510 (Jun 1909): 383-4. For bibliographical information about de Vries's works published in the United States, see *The Work of the Open Court Publishing Co.*, Chicago: The Open Court, 1908, pp. 92-5.

[276] Daniel T. MacDougal, "Studies in Organic Evolution" *Journal of New York Botanical Garden* (1905): 27-36, 36.

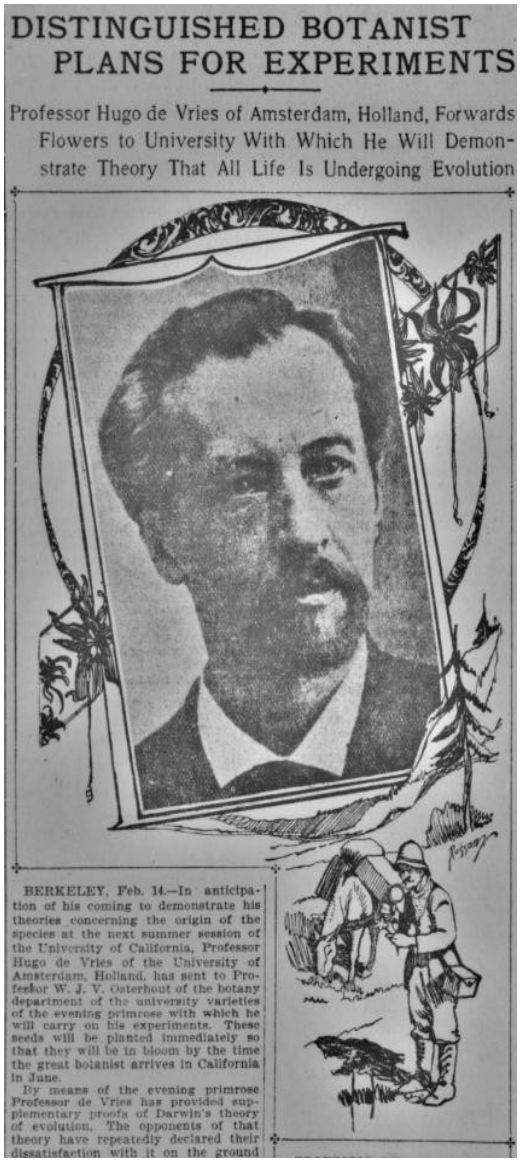
[277] Daniel T. MacDougal, "Hugo de Vries" *Open Court* 19.8 (1905): 449-453. For this aspect of MacDougal's campaign and its significance for professional breeders working at state experiment stations and agricultural colleges, see Sharon Kingsland, "The Battling Botanist: Daniel Trembly MacDougal, Mutation Theory, and the Rise of Experimental Evolutionary Biology in America, 1900-1912" *Isis* 82.3 (1991): 479-509; 494.

[278] "Books and Writers" *Evening Star* (25 May 1907): 8.

[279] "Plant-Breeding. By Hugo de Vries" *Athenaeum* (31 Aug 1907): 242-3. In the preface to *Species and Varieties*, de Vries clearly prioritized this motivation describing the work as published primarily "in the interest of agricultural and horticultural practice as well as in that of general biologic science" (vii).

In their struggle to establish professional authority, mutationists such as MacDougal promoted the image of botany as a thoroughly scientific discipline based on experimental plant breeding. A lively response to this campaign can be noted in one of the Californian daily newspapers, the *San Francisco Call* (Figure 5). In winter of 1904, the *Call* published a short note informing the readers about de Vries's upcoming visit to Berkeley including a photograph of de Vries and an engraving picturing an exemplary naturalist on a field trip, with a magnifying glass and box for specimen collection in hand.[280] Several months later the same newspaper announced the arrival of de Vries in California, picturing the botanist as an elderly man who regained his strength "in the midst of vistas crowded with his beloved flowers", offering a romanticized representation that echoed traditional depictions of gentlemen naturalists.[281]

[280] "Distinguished Botanist Plans for Experiments" *San Francisco Call* (15 Feb 1904): 6.
[281] "Flora Pleases Great Botanist" *San Francisco Call* (26 Jun 1904): 40.

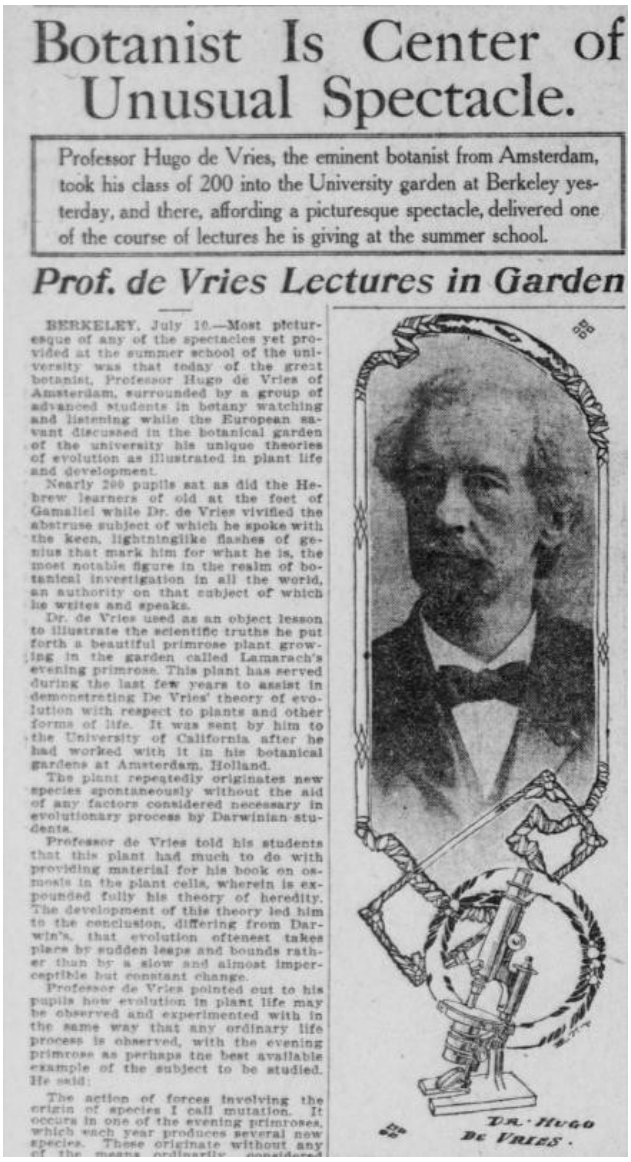


DISTINGUISHED BOTANIST PLANS FOR EXPERIMENTS

Professor Hugo de Vries of Amsterdam, Holland, Forwards Flowers to University With Which He Will Demonstrate Theory That All Life Is Undergoing Evolution

BERKELEY, Feb. 14.—In anticipation of his coming to demonstrate his theories concerning the origin of the species at the next summer session of the University of California, Professor Hugo de Vries of the University of Amsterdam, Holland, has sent to Professor W. J. V. Osterhout of the botany department of the university varieties of the evening primrose with which he will carry on his experiments. These seeds will be planted immediately so that they will be in bloom by the time the great botanist arrives in California in June.

By means of the evening primrose Professor de Vries has provided supplementary proofs of Darwin's theory of evolution. The opponents of that theory have repeatedly declared their dissatisfaction with it on the ground



Botanist Is Center of Unusual Spectacle.

Professor Hugo de Vries, the eminent botanist from Amsterdam, took his class of 200 into the University garden at Berkeley yesterday, and there, affording a picturesque spectacle, delivered one of the course of lectures he is giving at the summer school.

Prof. de Vries Lectures in Garden

BERKELEY, July 10.—Most picturesque of any of the spectacles yet provided at the summer school of the university was that today of the great botanist, Professor Hugo de Vries of Amsterdam, surrounded by a group of advanced students in botany watching and listening while the European savant discussed in the botanical garden of the university his unique theories of evolution as illustrated in plant life and development.

Nearly 200 pupils sat as did the Hebrew learners of old at the feet of Gamaliel while Dr. de Vries vivified the abstruse subject of which he spoke with the keen, lightninglike flashes of genius that mark him for what he is, the most notable figure in the realm of botanical investigation in all the world, an authority on that subject of which he writes and speaks.

Dr. de Vries used as an object lesson to illustrate the scientific truths he put forth a beautiful primrose plant growing in the garden called Lamarach's evening primrose. This plant has served during the last few years to assist in demonstrating De Vries' theory of evolution with respect to plants and other forms of life. It was sent by him to the University of California after he had worked with it in his botanical gardens at Amsterdam, Holland.

The plant repeatedly originates new species spontaneously without the aid of any factors considered necessary in evolutionary process by Darwinian students.

Professor de Vries told his students that this plant had much to do with providing material for his book on osmosis in the plant cells, wherein is expounded fully his theory of heredity. The development of this theory led him to the conclusion, differing from Darwin's, that evolution oftenest takes place by sudden leaps and bounds rather than by a slow and almost imperceptible but constant change.

Professor de Vries pointed out to his pupils how evolution in plant life may be observed and experimented with in the same way that any ordinary life process is observed, with the evening primrose as perhaps the best available example of the subject to be studied. He said:

The action of forces involving the origin of species I call mutation. It occurs in one of the evening primroses, which each year produces several new species. These originate without any

DR. HUGO DE VRIES.

Fig 5. Fragments of two newspaper features about de Vries. Source: *The San Francisco Call* 95.77 (15 February 1904): 6; *The San Francisco Call* 100.41 (11 July 1906): 6. Credits: Public domain, California Digital Newspaper Collection, Center for Bibliographic Studies and Research, University of California, Riverside, <http://cdnc.ucr.edu>.

By de Vries's second visit to California in 1906, the *San Francisco Call* constructed a radically different image of botany in a feature describing the highly unlikely "spectacle" of de Vries lecturing to two hundred students at the University botanic garden.[282] The photograph of the

[282] In one of his letters, de Vries mentioned the remarkably poor attendance of the 1906 Berkeley summer school: "De Summerchool is slecht bezocht, ongeveer zeshondert. Op mijn college komen er tien a twintig denk ik […] Alles is

botanist this time was paired with a detailed engraving of a microscope which signaled the departure of the public understanding of botanical research in terms dictated by the naturalist tradition.[283] This graphic element is an early example of a trend in American science popularization identified by Marcel LaFollette to rely on glamorizing laboratory equipment.[284]

### 3.3 *Mutation Travels to America – Theory and Practice*

Upon receiving financial assistance from the University of California,[285] de Vries embarked on a long and monotonous journey to the North American continent, spending most of the time in his cabin preparing for numerous lectures he was scheduled to give once on land.[286] Among the copious dinners and receptions organized by the local scientific circles, de Vries visited the New York Botanical Garden which was home to the enthusiastic mutationist, Daniel T. MacDougal.[287] As other young American scientists, MacDougal came into contact with the continental plant physiology during his travels to England, Germany, and Holland, while he completed his doctoral research working with eminent botanists such as Wilhelm Pfeffer and Hermann Vöchting. MacDougal was also aware of the scientific program proposed by de Vries's mentor from Würzburg, Julius von Sachs, whose ideas had a significant influence over American botanists, as Eugene Cittadino and Sharon Kingsland suggest in their studies of the history of American

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zonder enthousiasme, heel anders dan twee jaar geleden. De brand van San Francisco deprimeert ieder en alles […]" (qtd. in Zevenhuizen, Introduction to *O, Wies!*, 33).

283 "Botanist Is Center of Unusual Spectacle" *San Francisco Call* (11 Jul 1906): 6.

284 LaFollette, *Making Science Our Own*, 112.

285 According to Zevenhuizen, de Vries's travel was sponsored by the president of the University of California, Benjamin Wheeler (Introduction to *O, Wies! 't Is hier zo mooi!*, 23). This claim is confirmed in the letter exchange between the botanist and Wheeler (Wheeler to de Vries, 15 December 1903). However, Philip J. Pauly claims that Jacques Loeb in fact sponsored de Vries's visit to Berkeley in 1904, see *Controlling Life. Jacques Loeb and the Engineering Ideal in Biology*, New York: Oxford University Press, 1987: 108.

286 Zevenhuizen, Introduction to *O, Wies! 't Is hier zo mooi!*, 23.

287 For biographical sources on MacDougal, see Patricia Craig, "Daniel MacDougal: Engineer of Life," in *Centennial History of the Carnegie Institution of Washington*, Patricia Craig (ed.), Cambridge: Cambridge University Press, 2005, vol. 4: 37-56; Sharon E. Kingsland, *The Evolution of American Ecology*, Baltimore: Johns Hopkins University Press, 2005: 70-7; "Daniel Trembly MacDougal: Pioneer Plant Physiologist" *Plant Physiology* 14.2 (Apr 1939): 191-202. For MacDougal's mutation research, see Campos, *Radium and the Secret of Life*, Chapter 3.

ecology.[288] MacDougal strongly advocated de Vries's method of experimental breeding because it matched his progressive research agenda, and aggressive campaign for the public recognition of botany and evolutionary biology as experimental disciplines.[289] Actively opposing the naturalist tradition, MacDougal could easily serve as an exemplary figure symbolizing the radical division between morphologists and physiologists outlined by Garland Allen in a classic, even if frequently problematized, work on the history of American life sciences.[290] Combined with the firm belief in the economic value of heredity research, these interests rendered MacDougal an ideal spokesman for the mutation theory in the United States.

Numerous studies have demonstrated deep connections between the emergence of academic genetics in the United States and the long tradition of practical work carried out at state experiment stations and agricultural colleges.[291] In their examination of the motivations leading the advocates of Mendelism in America, Diane B. Paul and Barbara Kimmelman demonstrated how "the work of scientists at agricultural stations converged with that of an international group of botanists and hybridists interested in evolutionary problems".[292] Among these groups was Hugo de Vries, whose own scientific agenda had crystallized in the context of Dutch progressive liberalism, and had also been influenced by Julius von Sachs who employed the argument of agricultural benefit to raise the

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[288] Eugene Cittadino, "Ecology and the Professionalization of Botany in America, 1890-1905" *Studies in History of Biology* 4 (1980): 171-98, 176-7; Sharon E. Kingsland, *The Evolution of American Ecology*, 69-74. For the professionalization of genetics, see Jan Sapp, "The Struggle for Authority in the Field of Heredity, 1900-1932: New Perspectives on the Rise of Genetics" *Journal of the History of Biology* 16.3 (1983): 311-42.

[289] In an article for *Science* magazine, MacDougal states that "the main questions of descent and heredity and of evolution in general are essentially physiological, and as such their solution is to be sought in experiences with living organisms and not by deductions from illusory 'prima facie' evidence […] nor by 'interpretations of the face of nature'", see Daniel T. MacDougal, "Discontinuous Variation and the Origin of Species" *Science* 21.535 (7 Apr 1905): 540.

[290] Garland E. Allen, *Life Science in the Twentieth Century*, New York: Wiley, 1975.

[291] For a selection of studies on this topic, see Barbara Kimmelman, "A Progressive Era Discipline"; Deborah Fitzgerald, *The Business of Breeding: Hybrid Corn in Illinois, 1890-1940*, Ithaca: Cornell University Press 1989; Jack R. Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology, 1492-2000*, New York: Cambridge University Press, 1988; Diane B. Paul and Barbara Kimmelman, "Mendel in America. Theory and Practice," in *The American Development of Biology*, R. Rainger, Keith R. Benson and Jane Maineschein (eds.), Philadelphia: University of Pennsylvania Press, 1988: 281-310. For an early review of the scholarship on the topic, see Garland E. Allen, "History of Agriculture and the Study of Heredity – A New Horizon" *Journal of the History of Biology* 24 (1991): 529-36.

[292] Diane B. Paul and Barbara Kimmelman, "Mendel in America", 282.

status of physiology as an academic discipline in Germany.[293] By the time of his first journey to the United States, de Vries possessed ample experience in arguing for the practical value of pure botanical research to fellow scientists, professional farmers and horticulturists, as well as the general public.[294] The botanist correctly assumed that the practical implications of his work would be well-received by American audiences. In a letter exchange with the president the University of California, Benjamin Wheeler, de Vries offered to deliver a course on the topic: "I might propose to lecture during the six weeks of your summer-session, the practical side of my investigations on the origin of species by mutations".[295] The publication of the series of lectures as *Species and Varieties* perfectly captured de Vries's intention to offer the "means and methods by which the origin of species and varieties may become an object of agricultural and horticultural practice", in the words of a British reviewer.[296] In the second volume of his Berkeley lectures, de Vries openly stated that the "far-reaching agreement between science and practice is to become a basis for further development of practical breeding as well as for the doctrine of evolution".[297] British reviewers of the volume painted a similar picture of the theory, locating the central focus of the book to be "the manner in which this theory, by its application to plant-breeding, may be expected to effect a revolution in the means adopted by the practical breeder for improving his plants".[298]

The preoccupation with practical applications of scientific knowledge brought de Vries closer to the scientific agenda of MacDougal, whose entire career was guided by the interest in predicting and controlling scientific processes, articulated in the developing field of the American

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293 Theunissen, "Knowledge is Power", 298. See also Bert Theunissen, "The Scientific and Social Context of Hugo de Vries's Mutationstheorie" *Acta Botanica Neerlandica* 47.4 (1998): 475-89; Harro Maat, *Science Cultivating Practice. A History of Agricultural Science in the Netherlands and the Colonies, 1863-1986*, Dordrecht: Springer, 2001, Chapter 5.

294 See Zevehuizen, Introduction to *O, Wies!*, 30; and Theunissen, "Knowledge is Power", 296; 298-301.

295 Hugo de Vries to Benjamin Wheeler, 24 November 1903. University of California (System). Office of the President. Records: Alphabetical Files, CU-5, Series 1, University Archives, The Bancroft Library, University of California, Berkeley.

296 "Species and Varieties" *Scotsman* (13 Mar 1905): 2.

297 Hugo de Vries, *Plant-Breeding. Comments on the Experiments of Nilsson and Burbank*, Chicago: The Open Court, 1907: v.

298 "Plant-Breeding. By Hugo de Vries" *Athenaeum* (31 Aug 1907): 242-3.

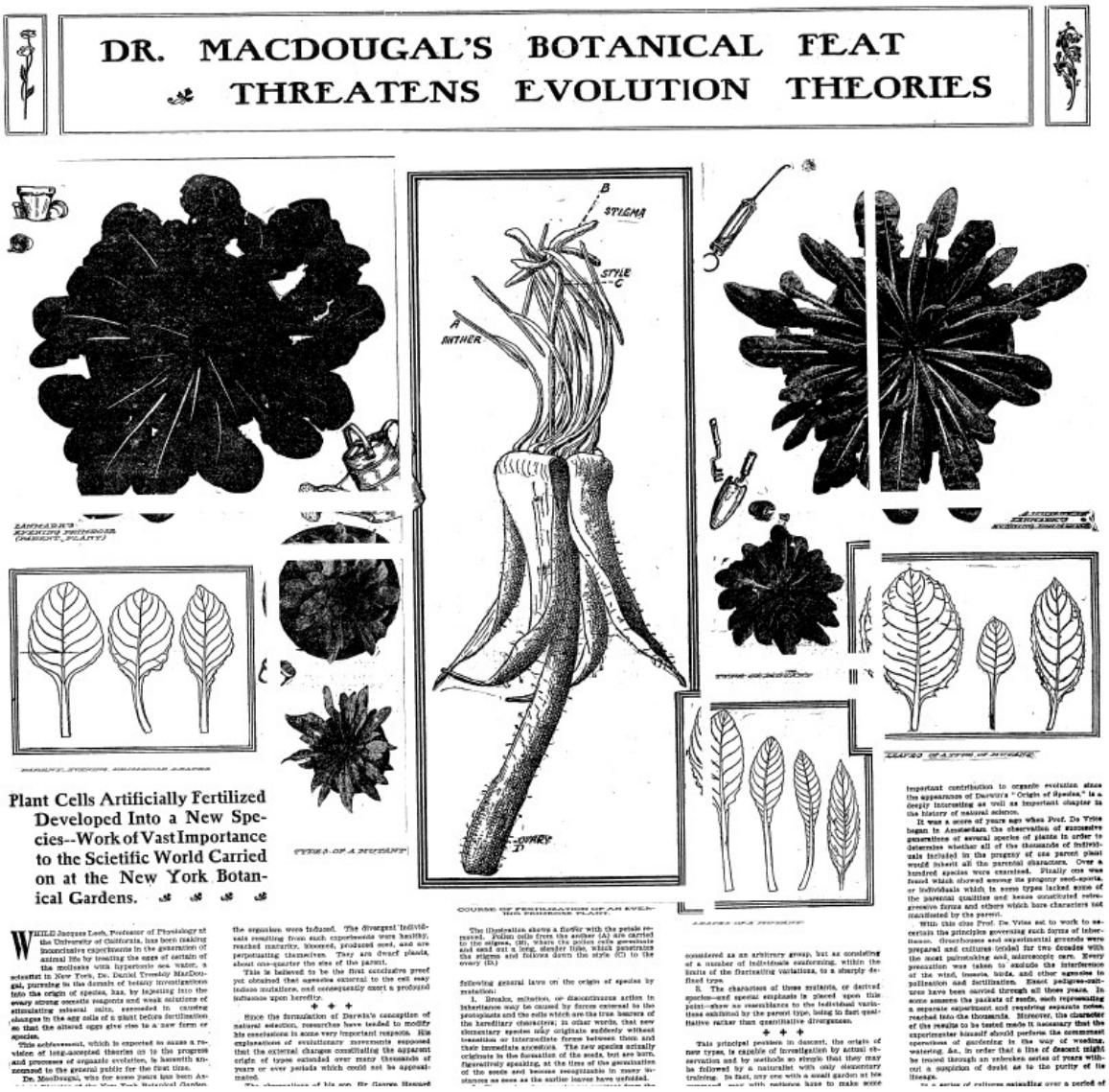
ecology.[299] In the early 1890s, MacDougal explored Arizona as an agent of the U. S. Department of Agriculture, and from 1903 until 1933, he served as the director of the Department of Botanical Research at the Carnegie Institution. He also founded the Desert Botanical Laboratory in Tucson, Arizona, as a center dedicated to examining the agricultural potential of desert environment.[300] The stream of generous funding directed toward establishing such research centers, or the endowment of a sum of $10,000 per year to an amateur horticulturist, Luther Burbank, demonstrate that scientific plant and animal breeding had been of interest to private patrons such as the Carnegie Institution in Washington.

MacDougal's insistence on promoting practical applications of the mutation theory motivated the formation of a particular understanding of experimental evolutionary biology articulated in the American press (Figure 6). MacDougal followed de Vries in believing that "as the breeder now controls variability, it should become possible to control mutability", and thus attempted to produce *Oenothera* mutations by injecting various chemical solutions – some of which contained radium – into the plant's ovaries right before fertilization.[301]

[299] For this aspect in early American ecology, see Kingsland, *The Evolution of American Ecology* 75, 150-2. In *Die Mutationstheorie*, de Vries declared that "when we have succeeded in finding the laws of mutation, we will not only be able to gain a much deeper insight into the mutual relationships of the living organisms, but we may also hope to be able to intervene in the mechanism of species formation" (qtd. in Theunissen, "Knowledge is Power", 303). He articulated a similar point in an article for the *Scientific American*: "Underlying all and directing all the efforts should be the hope of obtaining such a knowledge of the phenomenon as would enable us to take the whole guidance of it into our own hands" (Hugo de Vries, "Experimental Evolution", op cit. 10).

[300] "Daniel Trembly MacDougal, Pioneer Plant Physiologist", 192. For a detailed account of MacDougal's activities at the New York Botanical Garden and the Desert Laboratory, see Sharon Kingsland, *The Evolution of American Ecology*, Chapter 3 and 4.

[301] For a detailed overview of experiments with *Oenothera lamarckiana* conducted in New York, see Jim Endersby, *A Guinea Pig's History of Biology*, 158-9.



DR. MACDOUGAL'S BOTANICAL FEAT
THREATENS EVOLUTION THEORIES

Plant Cells Artificially Fertilized Developed Into a New Species--Work of Vast Importance to the Scietific World Carried on at the New York Botanical Gardens.

Fig 6. An example of a feature about MacDougal's experiments in the *New York Times*. Source: "Dr. MacDougal's Botanical Feat Threatens Evolution Theories" *New York Times* (24 Dec 1905): 1-2. Credits: https://search.proquest.com/docview/96521493?accountid=9652.

Among the extensive coverage of MacDougal's experiments figured a large feature article in the popular Sunday edition of the *New York Times*, published with a suggestive subtitle "Man Able to Change Form and Color of Flowers at Will", which reported the esteemed scientist to honestly believe "it to be entirely within the range of possibilities that [his] methods may be so extended as

to enable man, the conscious organism, to control and direct the evolution of the entire organic world".[302]

Around 1900, agricultural improvement had become a newsworthy subject, and heredity research was recognized by press editors all over the country as potentially beneficial for the "modification and improvement of animals and plants at man's will".[303] Editors running general-interest magazines and specialist publications exhibited a similar interest.[304] A chemistry professor writing for *Harper's Magazine* was not alone in believing that the "general principles of heredity formulated by Mendel give much promise in the way of crop improvement through more systematic method of breeding".[305] An outspoken figure who campaigned for the cause was Willet M. Hays, the director of the Minnesota experiment station, professor of agriculture at the University of Minnesota, and founder of the American Breeders Association (ABA). As Diane B. Paul and Barbara Kimmelman indicate, even though the ABA had varied membership, there existed a consensus about the laws of heredity formulated by Gregor Mendel, Francis Galton, and Hugo de

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302 "New Wonders of Science in Dealing With Plants" *New York Times* (4 Oct 1908): 8. MacDougal's work received public attention already in 1905; for press coverage of his mutation experiments, see "Dr. MacDougal's Botanical Feat Threatens Evolution Theories" *New York Times* (24 Dec 1905): 1-2; "Mutations of Plants" *Evening Star* (26 Dec 1905): 7; "Species by Mutation" *Evening Star* (2 May 1906): 11; "Expanding the Work of Desert Laboratory" *Arizona Republican* (5 May 1906): 12; "The Week in the World" *Windham County Reformer* (27 Jul 1906): 2; Russell A. Bond, "The War for Existence" *San Francisco Call* (14 Oct 1906): 2.

303 John Elfreth Watkins, "Creation of Species" *New York Daily Tribune* (24 Feb 1907): 2. For other examples of press articles examining practical applications of heredity science, see "Educational Work by Fruit-Growers" *San Francisco Call* (21 Feb 1900): 4; "An Advance in Biology" *New York Daily Tribune* (5 Oct 1902): 3; "An Advance in the Science of Biology" *Ranch* (1 Nov 1902): 4; "New Order of Farmers" *Los Angeles Herald* (1 Mar 1903): 7; Charles A. Zavitz "The Improvement of Cereal Crops" *Kansas Farmer* 44.12 (22 March 1906): 307-8; Frederic J. Haskin,"The Carnegie Institution" *Los Angeles Herald* (16 Mar 1908): 4; Frederic J. Haskin, "When America is Grown – Agriculture" *Los Angeles Herald* (6 Jun 1908): 4; M. R. James, "The Experiment in Selective Breeding for Egg-Production" *Pacific Rural Press* (3 Oct 1908): 219; G. W. Shaw, "The Possibilities of Plant Improvement in California" *Pacific Rural Press* (9 Jan 1909): 24; "An Exposition of the Future" *Sacramento Union* (29 Nov 1909): 3; "Laws of Heredity Exemplified in Products to Be Shown at Corn Exposition" *Sacramento Union* (3 Dec 1909): 4.

304 For examples of magazine features on the topic, see H. Gilson Gardner, "Creating New Fruits" *The Cosmopolitan* 37 (Jul 1904): 262-66; John Brisben Walker, "XVI. Scientific Agriculture" *Cosmopolitan* 37 (Sep 1904): 581-92; René Bache, "The Riddle of Heredity" *Saturday Evening Post* (17 Jun 1905): 13; E .T. Brewster, "Breeding Plants and Animals to Order" *World's Work* 15 (Dec 1907): 9653-8; Edward C. Parker, "The Future Wheat Supply of the United States" *Century Illustrated Monthly Magazine* 76 (Sep 1908): 736-46; R. C. Punnett, "Applied Heredity" *Harper's Monthly Magazine* 118 (Dec 1908): 115-22; David Buffum, "Science and Sense in Farming" *Saturday Evening Post* 182 (11 Sep 1909): 8-9; J. Russel Smith, "Making Plants and Fruits to Order" *Everybody's Magazine* 25 (Sep 1911): 373-4, J. Russel Smith, "The Agriculture of the Future" *Harper's Monthly Magazine* 126 (Jun 1913): 273-81.

305 Harry Snyder, "What Science Does for Farm Crops" *Harper's Monthly Magazine* 115 (Oct 1907): 729-32.

Vries which "could readily be used to improve artificial selection".[306] Hays made the issue into the central topic of his inaugural address at the very first meeting of the ABA, and exploited it in his numerous public statements about the state of American agriculture.[307] An article from a Kansan newspaper turned to Hays when discussing the 1902 International Conference on Plant Breeding and Hybridization in New York, suggesting that the preceding one held in 1899 in London had been disappointing precisely because it did not provide a forum for discussing the role of hybridization in the national economy.[308] By the end of the decade, the editors of the *American Breeder's Magazine* would wax poetic about the value of theoretical knowledge about heredity as "far above that of gold" to the American nation, drawing a picture of the perplexing hereditary mechanism as "more subtle and more marvelous than electricity", and once "new breeding values are created they continue as permanent economic forces".[309]

Promising to accelerate crop improvement by creating artificial mutations, de Vries's theory offered a utopian vision of agriculture which found its clearest articulation upon the botanist's third and last journey to the United States in 1912. De Vries began his travel in New York, where he gave a free public lecture at the New York Botanical Garden. A detailed coverage of the event in the *New York Times* had the Garden's director state that the "secret of the future is to be able to repeat exactly by agriculture the mutations as observed now in nature".[310] De Vries lectured on a similar topic a few days later at the meeting of the Botanical Society of Washington, but the coverage offered in the *Washington Post* had a decisively sensational ring to it. The botanist's theoretical insights were presented as a solution to the problem of impending global famine, suggesting how "only great strides by science could save the world of future years from

[306] Diane B. Paul and Barbara Kimmelman, "Mendel in America", 281.
[307] Willet M. Hays, "Address by Chairman of Organization Committee" *Proceedings of the American Breeders Association*, 1905: 9-15. See also Willet M. Hays, "Recent Science in Plant and Animal Breeding" *Pacific Rural Press* 80.4 (23 July 1910): 64.
[308] "How Plants Are Changed" *Wichita Daily Eagle* (17 Aug 1902): 17.
[309] "Heredity: Creative Energy" *American Breeder's Magazine* 1.2 (1910): 79.
[310] "The Way to Increase the World's Foods" *New York Times* (15 Sep 1912): 15.

starvation".[311] By the end of the month, the *New York Times* chose to devote an entire page of its Sunday edition to a feature article exploring de Vries's theory as an alternative to the long and unstable process of artificial selection, drawing a vision of the mutation theory as offering "endless possibilities for the increase of productivity of any given area of land".[312] This interpretation of the mutation theory reverberated all over the United States, shaping, as Jim Endersby persuasively argues, the ideological foundation for incorporating utopianism into the public culture of biology in the twentieth century.[313]

Jonathan Harwood noted that the theoretical framework of Mendelism did not revolutionize the practice of breeding, but it did affect the area in three ways: "It provided a scientific explanation for breeding practice; it allowed breeders to reflect upon the adequacy of existing practices, and it served as a heuristic to open up the possibility of improved methods".[314] Even if historical studies exploring the relations between breeding practices and biological theory show that numerous breeders and naturalists did not share these hopes about Mendelism, the American audiences were continuously exposed to far-reaching statements about the practical potential of de Vriesian mutations and Mendelism.[315] Considering that despite years of intense research conducted by numerous American mutationists no profitable mutations ever appeared on the market, the unceasing public interest may seem perplexing. Apparently, what allowed the mutation theory – and by extension Mendelism – to thrive in the context of agricultural improvement was the strong

311 "Fears World Famine" *Washington Post* (19 Sep 1912): 4.

312 "Noted Holland Expert Tells How to Double Our Crops" *New York Times* (29 Sep 1912): 14.

313 See Endersby, "Mutant Utopias" 477. For examples of such coverage, see "Increase Vegetation or We Will Starve" *Evening Star* (19 Sep 1912): 11; "How to Increase World's Foods" *Citizen* (2 Oct 1912): 3; "Grow Larger Grain" *Essex County Herald* (11 Oct 1912): 2; "Grow Larger Grain" *Celina Democrat* (18 Oct 1912): 6; "World Doomed to Starve" *Boston Evening Transcript* (3 Dec 1912): 14.

314 Jonathan Harwood, "Did Mendelism Transform Plant Breeding? Genetic Theory and Breeding Practice, 1900-1945", in *New Perspectives on the History of Life Sciences and Agriculture*, Sharon Kingsland and Denise Phillips (eds.), Cham: Springer, 2015: 345-370, 346.

315 See Harwood, "Did Mendelism Transform Plant Breeding?"; Nils Roll-Hansen, "Theory and Practice: The Impact of Mendelism on Agriculture" *Comptes Rendus de l'Académie des Sciences Paris, Sciences de la Vie* 323.12: 1107-16; Pallo Palladino, "Between Craft and Science: Plant Breeding, Mendelian Genetics, and British Universities, 1900-1920" *Technology and Culture* 34 (1993): 300-323; Deborah Fitzgerald, *The Business of Breeding*.

public association of de Vries's theoretical work with the highly profitable breeding experiments conducted by the Californian "Wizard of Horticulture",[316] Luther Burbank.

### 3.4 *Mutation Meets Hybridization*

When de Vries visited California for the first time, the American agriculture had already assumed the form of a lively and diverse webs of relations established between seed dealers, nurserymen, market gardeners, horticulturalists and farmers. The globalization of the seed market allowed breeders to import foreign seeds, grow exotic species under various conditions, and cross them with local varieties to achieve particular results.[317] Such strategy for creating agricultural novelties was at the core of the practice employed by the renowned Luther Burbank, present in the American public imagination since the early 1890s as an iconic self-taught plant breeder.[318] Burbank introduced numerous more or less lucrative organic "inventions" to the American market, such as the russet potato, the seedless plum, or the spineless cactus. He swiftly became recognized as a national hero, to the extent that an unfavorable opinion about his methods expressed by an English editor became headline news.[319] Inspired by his reading of Charles Darwin's *The Variation of Animals and Plants Under Domestication*, Burbank left the harsh climate of Massachusetts and, guided by the prevalent agrarian myth of California, launched a large-scale project of improving fruit and vegetable varieties at a plantation in Santa Rosa, Sonoma County. Upon his first visit to

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316 "California's Great Plant Specialist" *San Francisco Call* (8 Mar 1896): 15.

317 For scholarship on nineteenth- and early twentieth-century American agriculture, see Philip J. Pauly, *Fruits and Plains: The Horticultural Transformation of America*, Cambridge, MA: Harvard University Press, 2007; Susan Warren Lanman, "'For Profit and Pleasure': Peter Henderson and the Commercialization of Horticulture in the Nineteenth-Century America," in *Industrializing Organisms: Introducing Evolution History*, Susan Schrepfer and Philip Scranton (eds.), New York: Routledge, 2004: 19-43; ibid, "The Rise of the Industrial Garden", PhD thesis, University of Denver, 1998. For Californian agriculture, see Alan L. Olmstead and Paul W. Rhode, "The Evolution of California Agriculture, 1850-2000," in *California Agriculture: Dimensions and Issues*, Jerome B. Siebert (ed.), Oakland: University of California Press, 2004: 1-28, Kevin Starr, *Inventing the Dream: California Through the Progressive Era*, New York: Oxford University Press, 1985, Chapter 5.

318 For sources examining the myth of Luther Burbank, see Walter L. Howard, *Luther Burbank: The Victim of Hero Worhsip*, Waltham, MA: The Chronica Botanica, 1945.

319 "Englishman Calls Burbank Merely a Poor Imitator" *San Francisco Examiner* (5 Aug 1906): 1.

the United States, De Vries had been familiar with Burbank's work. Several months before his journey, the botanist wrote to the president of the University of California, Benjamin Wheeler: "I had the honour of exchanging some letters with Mr. Burbank, and confidently hope that he will be kind enough to show me his experimental gardens. They are for me one of the greatest attractions of California […]".[320]

Accompanied by the eminent experimental zoologist Jacques Loeb, de Vries paid Burbank a visit in 1904, hoping to unveil the horticulturist's methodology for obtaining such remarkable results. Even though de Vries publicly admired the scale of Burbank's enterprise, this and other visits turned out to be disappointing.[321] In *Plant Breeding*, de Vries sustained that Burbank's success had been founded on nothing else than well-known hybridization techniques. This opinion, expanded in an article de Vries wrote for the *Century Illustrated*, was quickly picked up by newspaper editors and spread throughout the Californian press.[322] Even if editors often pictured Burbank as a "man of science", his belonging to this professional category was repeatedly questioned by scientists themselves, especially those involved in the generous grant the Carnegie Institution bestowed upon Burbank in 1905.[323] While the press optimistically predicted that as "science and Mr. Luther Burbank have at last made one another's [sic] acquaintance", the "outcome should be to their mutual advantage",[324] botanists sent to investigate Burbank's methodology and

[320] Hugo de Vries to Benjamin Wheeler, 9 January 1904, (op cit. 57).

[321] Hugo de Vries, "A Visit to Luther Burbank" *Popular Science Monthly* (Aug 1905): 340, 344; ibid, "Personal Impressions of Luther Burbank" *Independent* (17 May 1906): 1134-40.

[322] Hugo de Vries, *Plant-Breeding*, 160. For a another source of de Vries's opinion on Burbank, see "Luther Burbank's Ideas on Scientific Horticulture" *Century Illustrated Monthly Magazine* 73.51 (Mar 1907): 675-81. For newspaper coverage of de Vries's view, see "March Magazines" *Los Angeles Herald* (26 Feb 1907): 9; "Gossip of Books and People Who Made Them" *San Francisco Call* (12 Aug 1907): 13. Kingsland argued that Burbank's popularity and his negative opinion about de Vries's mutation theory had been used by scientists such as Vernon L. Kellog or David Starr Jordan to compromise the mutationists, see "The Battling Botanist", 497-8.

[323] For an overview of Luther Burbank's problematic status in the scientific community, see Katherine Pandora, "Knowledge Held in Common: Tales of Luther Burbank and Science in the American Vernacular" *Isis* 93.2 (2001): 484-516. For his role in rendering horticulture a scientific field, see Margaret Rossiter, "The Organization of the Agricultural Sciences," in *The Organization of Knowledge in Modern America, 1860–1920*, Alexandra Oleson (ed.), Baltimore: Johns Hopkins University Press, 1979.

[324] E. T. Brewster, "Breeding Plants and Animals to Order" *World's Work* 15 (Dec 1907, 9653-8): 9655.

records returned empty-handed.[325] Even if the public associated Burbank with a stereotype reserved for scientists –the creator of life, at the time shared with Jacques Loeb[326] – other voices offered a contrasting vision of Burbank by showing how the horticulturist had "upset theories of the botanists of yesterday and of to-day [and] accomplished that which was said to be an utter impossibility – the creation of new species in plant life".[327] As the decade progressed and Burbank's venture became incorporated, editors gladly reported that "his work will for the future be exploited in a commercial rather than a scientific spirit […] wholly in accord with the temper and tendencies of an age severely practical and wedded to economic uses".[328]

The conflicting public image of Burbank as a man of science or self-taught inventor in the vein of Thomas Edison permeated the public imagination of California, and had an impact on the representation of the mutation theory. As soon as de Vries reached California, editors began to represent the botanist and Luther Burbank as two sides of the same coin, emphasizing how the theory of mutation represents "the theoretical aspect of that which Mr. Burbank has accomplished practically in his experimental gardens".[329] By his second visit to the state, de Vries developed a rather skeptical view of Burbank's haphazard methodology. However, until 1907 he still publicly recognized the horticulturist's achievement – in a short interview for the *Salt Lake Herald*, the botanist stated the following: "The methods of Professor Burbank and my own are somewhat similar […] with this difference: his is practical work, while mine is theoretical. I find the way and let others secure the results. He secures the results".[330] The extensive coverage of de Vries's theory in the context of agricultural improvement, and his close association with the celebrated Burbank powered the public awareness of the growing gulf between the traditional idea of farming and the

[325] Bentley Glass, "The Strange Encounter of Luther Burbank and George Harrison Shull" *Proceedings of the American Philosophical Society* 124.2 (29 Apr 1980): 133-153.
[326] This stereotype is indicated by LaFollette, *Making Science Our Own*, 103-6.
[327] Norman Howard, "Dr. Luther Burbank, the Magician of Plants" *Quiver* (Jan 1906): 451-7.
[328] "The Incorporation of Genius" *San Francisco Call* (27 Feb 1909): 10.
[329] "University Events" *San Francisco Call* (7 Feb 1904): 39.
[330] "Dutch Botanist Here to Study" *Salt Lake Herald* (8 Aug 1906): 10.

reality of the Californian agriculture, with its immense fruit and nut tree plantations spawning an industry for canning, packing and transportation. Initiated in the last quarter of the nineteenth century, the process of governmental expansion over American agriculture, symbolically marked with the passing of the Adams Act in 1906, allowed for the introduction of the scientific methodology into a field previously exclusive to farmers, horticulturalists and nurserymen.[331] The rise of a truly scientific variant of agriculture found its clearest expression in 1914 upon the creation of the University of California Citrus Experiment Station in Riverside, where scientists in cooperation with the California Fruit Growers Exchange would apply scientific knowledge about plant heredity in experiments with orange mutations and hybrids.[332]

As the press emphasized the increasing presence of scientific knowledge in agriculture and problematized the pastoral image of nature which fueled the national culture of farming, the American audiences – especially those located in California – reexamined their understanding of the natural environment guided by the influential tenets of the conservation and preservation movements. It is telling that events later recognized as touchstones of the American environmentalist history occurred in the state where the Gold Rush and growing agriculture had taken a great toll on the natural landscape. Beginning in the nineteenth century, numerous Americans acted on a widespread anti-urban sentiment and professed back-to-nature lifestyles,[333]

[331] For sources exploring the relation between science and agriculture at the turn of the twentieth century, see Sharon E. Kingsland, *The Evolution of American Ecology*; Eugene Cittadino, "Ecology and the Professionalization of Botany in America, 1890-1905"; Paolo Palladino, "Wizards and Devotees: On the Mendelian Theory of Inheritance and the Professionalization of Agricultural Science in Great Britain and the United States, 1880-1930" *History of Science* 32 (1994): 409-44. For the significance of the Adams Act on professionals working at state experiment stations, see Charles E. Rosenberg, *No Other Gods: On Science and American Social Thought*, Baltimore: The Johns Hopkins University Press, 1997, Chapter 10.

[332] Douglas Sackman, "Inside the Skin of Nature: Science and the Quest for Golden Orange," in *Science, Values and the American West*, Stephen Tchudi (ed.), Reno: Nevada Humanities Community, 1997. For a detailed examination of the topic, see Douglas Sackman, *Orange Empire: California and the Fruits of Eden*, Berkeley: University of California Press, 2005.

[333] For back-to-nature lifestyles, see Lutts, *The Nature Fakers*; Kevin C. Armitage, *The Nature Study Movement: The Forgotten Popularizer of America's Conservation Ethic*, Westbrooke: University Press of Kansas, 2009; Elizabeth Keeney, *The Botanizers. Amateur Scientists in Nineteenth-Century America,* Chapel Hill: The University of North Carolina Press, 1985; Stephen Fox, *The American Conservation Movement. John Muir and His Legacy*, Madison: The University of Wisconsin Press, 1981; Peter J. Schmitt, *Back to Nature. The Arcadian Myth in Urban America*, New York: Oxford University Press, 1969; Arthur A. Ekrich, *Man and Nature in America*, New York: Columbia University Press, 1963.

inspired by environmentalists such as George Perkins Marsh, Henry David Thoreau, and John Muir.[334] In his influential writings, Muir constructed a narrative of nature which represented the Californian wilderness as spiritually superior to the artificial civilized landscape. He enriched the natural environment of the Southwest with a sense of spirituality, and did so together with Mary Austin, a key figure in Californian literary circles, and incidentally a close friend of Daniel T. MacDougal, with whom she shared a common ecological perspective on nature.[335]

This period also witnessed the establishment of the first American environmentalist movement which cultivated a vision of nature unviolated by civilization, recognized in contemporary criticism as the problematic notion of the wilderness.[336] The concept resonated in California, a state still enveloped in the frontier myth and the imagination of the Wild West. By the turn of the century, the idea of preserving the wilderness, realized in the creation of the national park at Yosemite, spread through the Californian middle classes and gained the support of women clubs and societies, bringing to life the influential Sierra Club, founded by Muir in 1892, and the Sempervirens Club in 1900.[337] Interestingly, scientists contributed to the installation of the wilderness narrative in the public sphere as occasional spokesmen for the preservation movement.[338] John Muir had himself received training in geology and botany at the University of Wisconsin, but

[334] Key figures and intellectual currents of American environmentalism are examined by Robert L. Dorman, *A Word for Nature. Four Pioneering Environmental Advocates, 1845-1913*, Chapel Hill: The University of North Carolina Press, 1998. For biographical information on John Muir, see: Donald Worster, *A Passion for Nature: The Life of John Muir*, Oxford: Oxford University Press, 2008.

[335] For MacDougal's collaboration with Austin, see Sharon E. Kingsland, "An Elusive Science: Ecological Enterprise in the Southwestern United States," in *Science and Nature: Essays in the History of Environmental Sciences*, Michael Shortland (ed.), Oxford: British Society for the History of Science, 1993: 151-180; 173. For the influence of Muir and Austin on the landscape of the Southwest, see John Gatta, *Making Nature Sacred: Literature, Religion and Environment in America from Puritans to the Present*, Oxford: Oxford University Press, 2004, Chapter 7.

[336] For classic criticism of the wilderness concept, see: William Cronon, "The Trouble with Wilderness; or, Getting Back to the Wrong Nature," in *Uncommon Ground. Rethinking the Human Place in Nature*, William Cronon (ed.), New York: W. W. Norton, 1995: 69-90. See also Michael Lewis (ed.), *American Wilderness. A New History*, Oxford: Oxford University Press, 2007.

[337] Richard Walker, *The Country in the City. The Greening of the San Francisco Bay Area*, Seattle: University of Washington Press, 2007: 19-31.

[338] For an examination of the scientists' involvement in the preservation movement, especially David Starr Jordan and a Stanford botanist William Dudley, see William S. Yaryan, "Saving the Redwoods: The Ideology and Political Economy of Nature Preservation" PhD dissertation, University of California Santa Cruz, 2002, Chapter 5. For John C. Merriam, see Stephen R. Mark, *Preserving the Living Past. John C. Merriam's Legacy in the State and National Parks*, Berkeley: University of California Press, 2005.

chose to leave formal education for what he called the "University of the Wilderness".[339] An active member of both clubs was David Starr Jordan, the president of Stanford University and close friend of Luther Burbank, a charter member of the latter association and an enthusiast of Muir's understanding of the natural environment.[340]

During his first visit to California, de Vries had been invited or a trip to the Big Basin Redwoods State Park by the Sempervirens Club and it is quite certain that he met John Muir during the expedition.[341] The theory of mutation came into contact with Muir's powerful narrative of nature, perpetuated by the preservation movement, in a less literal sense as well. The Californian editors employed the concept of artificiality as the central theme in their interpretations of experimental research into evolution and its impact on the American agriculture. Edward J. Wickson, a passionate popularizer and dean of the California College of Agriculture, called organisms produced through scientific breeding "strictly natural", but he noted that the "so-called 'lover of nature' calls them monsters".[342] Burbank's hybridization achievements inspired American audiences to speculate about the degree of biological mastery available to humanity, showing how "Man has proved [sic] his control of vegetable life. He takes it out of the slow hands of nature and hastens its evolution from one form to another […] By combination and evolution he produces new forms at will, and endows them with economic values that nature left undeveloped".[343]

Even though Burbank's reliance on hybridization for many made him a national hero, there existed an audience which accused him of transgressing "God's laws in nature", as he admitted in an

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339 John Muir, *The Story of My Boyhood and Youth* in: *The Wilderness World of John Muir*, Edwin Way Teale (ed.), Boston: Houghton Mifflin Company, 1954: 72.

340 See Kevin Starr, *Americans and the California Dream, 1850-1915*, Oxford: Oxford University Press, 1973: 189-191.

341 De Vries never mentioned Muir in his description of the journey in *Naar Californië* (Zevenhuizen, *O, Wies! 't Is hier zo mooi!*, 26), it is quite certain that they had met – Muir served as a pillar of the club and, as reported by a local newspaper, he was the guide on that same trip of 16 to 18 of July 1904, see "Sempervirens Club to Visit the Big Basin" *San Francisco Call* 96.43 (13 Jul 1904): 14. De Vries's participation in this excursion was noted two days later in the same newspaper, see "Personal" *San Francisco Call* 96.45 (15 Jul 1904): 7.

342 Edward J. Wickson, "The Industrial Use of Imagination" *Pacific Rural Press* (20 Jan 1906): 36. For more information about Wickson, see Kevin Starr, *Inventing the Dream,* 137-9.

343 "Science and Life" *San Francisco Call* (1 Feb 1906): 8.

interview for *The New York Times*.[344] One such episode occurred at a local church, where a minister had supposedly invited Burbank and proceeded to condemn him as "working in direct opposition to the will of God in thus creating new forms of life, which never should have been created, or, if created, only by God Himself".[345] William S. Harwood, Burbank's biographer, gave account of this episode as well, describing Burbank being accused of "interrupting the well-ordered course of plant life, destroying forces and functions long established and sacred, reducing the vegetable life to a condition at once unnatural and abnormal".[346] Even if "Mr. Burbank has never aimed at the production of bizarre, uncouth 'freaks' or 'unholy monsters'",[347] he had fallen victim to criticism which has long been part of the public perceptions of manipulating the hereditary traits of living organisms.

At the onset of the twentieth century, the Kansan *Wichita Daily Eagle* published an article which offered a brief history of plant hybridization, adding that once "more scientific and persistent lines of investigation were adopted, the pioneers were opposed by popular prejudice, objection being raised to their work on the ground that it was an impious interference with the laws of nature".[348] Throughout history, breeders such as Thomas Fairchild who experimented with hybridization techniques felt compelled to provide extensive justification for their actions, aware that others might interpret them as an insult to God's creation, a monstrous practice which problematized fixity of species, and offered what two American physicians called a "forbidden sight of the secret work-room of nature".[349] Such methods found opposition in the United States most

[344] "Luther Burbank: The Man and His Mind" *New York Times* (5 Aug 1906): 17.
[345] Norman Howard, "Dr. Luther Burbank, the Magician of Plants" *Quiver* (January 1906): 454.
[346] William S. Harwood, "A Wonder-Worker of Science" *Century Illustrated Magazine* (March 1905): 657. See also William S. Harwood, *New Creations in Plant Life. An Authoritative Account of the Life and Work of Luther Burbank*, New York: The Macmillan Company, 1905.
[347] Norman Howard, "Dr. Luther Burbank", 454.
[348] "How Plants Are Changed" *Wichita Daily Eagle* (17 August 1902): 17.
[349] George M. Gould and Walter L. Pyle, *Anomalies and Curiosities in Medicine. Being an Encyclopedic Collection of Rare and Extraordinary Cases, and of the Most Striking Instances of Abnormality in all Branches of Medicine and Surgery, Derived form an Exhaustive Research of Medical Literature from its Origin to the Present Day*, Philadelphia: W. B. Saunders, 1900: 1. For history of plant hybridization, see Noel Kingsbury, *Hybrid. The History and Science of Plant Breeding*, Chicago: University of Chicago Press, 2009; Conway Zirkle*, The Beginnings of Plant Hybridization*, Philadelphia: University of Pennsylvania Press, 1935.

notably from John Chapman, nicknamed Johnny Appleseed – a pioneer nursery man who preceded Luther Burbank in achieving the status of a mythical horticulturist.[350] Chapman reportedly said "that [grafting] is only a device of man […] and it is wicked to cut up trees that way. The correct method is to select good seeds and plant them in good ground and God only can improve the apple".[351] Charles Darwin addressed this issue in the introduction to *The Variation of Animals and Plants Under Domestication* which as we know influenced Burbank's plant-breeding methodology: "It is an error to speak of man 'tampering with nature' and causing variability. If organic beings had not possessed an inherent tendency to vary, man could have done nothing".[352] The second edition of the volume included an additional sentence to strengthen the argument, suggesting that the issue was of importance to a late nineteenth-century readership.[353]

In the early twentieth century, the criticism already addressed by Darwin resurfaced as a discursive source for interpreting scientific attempts at hereditary modification in terms of "faking nature". It is telling that in 1909, the Californian public could still read sensational news about a "Nightmare Hybrid" created by one of the scientific "nature fakers" who supposedly produced an orange with cucumber skin.[354] A few years earlier, the readers of the *San Francisco Chronicle* could read first-page news about scientists associated with the U. S. Department of Agriculture "evolving" a new orange hybrid that could sustain frost. The feature referred to the work of Herbert John Webber, an eminent plant physiologist who would become the director of University of California Citrus Experiment Station in Riverside.[355] When writing about "the greatest of all nature fakers [who were] at the employ of the national government", the author of the *Salt Lake Tribune*

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350 See William Kerrigan, *Johnny Appleseed and the American Orchard. A Cultural History*, Baltimore: The Johns Hopkins University Press, 2012.

351 Quoted in Kingsbury, *Hybrid*, 132.

352 Charles Darwin, *The Variation of Animals and Plants Under Domestication*, London: John Murray, Volume I, 1st edition, 1868: 2.

353 Ibid, *The Variation of Animals and Plants Under Domestication*, London: John Murray, Volume I, 2nd edition, 1875: 2. The American edition of the work, with a preface by Asa Gray, was printed in 1868 and consequently did not include this alteration.

354 "Nightmare Hybrid" *Los Angeles Herald 36.106* (15 Jan 1909): 4.

355 "An Orange Which Can Stand Frost" *San Francisco Chronicle* (15 Nov 1902): 1.

feature quoted at the beginning of this chapter represented the experimental breeding of rats and guinea pigs undertaken by E. C. Schroeder, a veterinary doctor and superintendent of the Bureau Experiment Station in Bethesda, Maryland. Privately conducted "nature faking" drew public attention as well. Newspapers ranging from the prestigious *New York Times* to the popular *Evening Star* offered detailed coverage of the experimental program realized at the Station for Experimental Evolution at Cold Spring Harbor, foregrounding findings regarding "freak" animals and insects, or Charles Davenport's "curious collection of cats".[356]


The San Francisco Sunday Call

Freak Farms Producing Furs, Feathers and Foods

Read This Article and Decide Which Kind of Grower You'd Rather Be

ON A CALIFORNIA OSTRICH FARM

A PET ON A COLORADO DEER FARM

Fig 7. Fragment of a newspaper feature. Source: *The San Francisco Call* 107.61 (30 January 1910): 3. Credits: Public domain, California Digital Newspaper Collection, Center for Bibliographic Studies and Research, University of California, Riverside, <http://cdnc.ucr.edu>.

From Jacques Loeb's controversial artificial fertilization experiments to MacDougal's creations recognized as "the first species ever produced with the aid of artificial means", from "freak farms" based on artificial rearing of sponges to nurserymen arguing that plants should be

[356] "Experimental Evolution of Long Island" *New York Times* (3 Jun 1906): 1; John Elfreth Watkins, "New Species to Order" *Evening Star* (23 Feb 1907): 8.

advertised as “pedigreed”, a survey of press articles conveyed the emergence of a scientific interest aptly called by Loeb the “technology of living substance” (Figure 7).[357] At the time of de Vries's first visit to California, the *San Francisco Examiner* ran a feature article in its popular Sunday edition exploring the latest “freak fruits”, among which were listed such peculiarities as Burbank's white blackberry, the “potato-tomato”, the “shooting cucumber”, monogrammed apples, and perpendicular tomatoes – all illustrating how “science [had] assumed the role of creator”.[358] The quality of artificiality permeated the language used by the Californian editors to describe plants and animals generated through scientific breeding. Influenced by the preservationist narrative of nature, the American press depicted “freak farms”, “nature fakes”, and scientists, able to “deliberately, purposefully and scientifically so distort plant and animal life as to make an unrecognizable hybrid”, suggesting that scientific intervention into living organisms deprived them of the spiritual purity Muir ascribed to nature.[359] Paradoxically, Muir rendered the idea of wilderness accessible to the genteel middle classes of the late nineteenth century through frequent comparisons with tamed, humanized and quintessentially artificial forms of the environment such as lawns, groves and gardens.[360]

In his sweeping historical survey of the American political economy of plant breeding, Jack R. Kloppenburg argued that the rediscovery of Mendel's work in 1900 “promised to put plant improvement on a much more sophisticated basis and make a 'science' of what was until that time recognized as an 'art'”.[361] The recognition of the practical value embedded in scientific research into heredity, powered by public expositions of the mutation theory and Mendelism, lead the American

[357] Jacques Loeb to Ernst Mach, quoted in Pauly, *Controlling Life*, 51. For examples of such press content, see A. Russell Bond, “The War for Existence” *San Francisco Call* (14 Oct 1906): 2; “Freak Farms Producing Furs, Feather and Food” *San Francisco Call* (30 Jan 1910): 3; “Pedigreed Stock: Does it Pay?” *Pacific Rural Press* (8 Jul 1911): 25.

[358] René Bache, “Freak Fruits” *San Francisco Examiner* (10 Jul 1904): 10.

[359] F. B. Morse, “Uncle Sam's Official Nature Fakers”, 6. For examples of such coverage, see “Woman Says Monster Frog Ate Her Chicks” *Los Angeles Herald* (27 Jul 1908): 2; “Good Housewives, Look Who's Here!” *Sacramento Union* (26 Jun 1909): 3; “The Very Latest Product of the nature Fake Factories” *San Francisco Chronicle* (17 Sep 1911): 11; “King Apple Holds Carnival” *San Francisco Call* (21 Aug 1912): 4.

[360] Dorman, *A Word for Nature*, 142-8.

[361] Kloppenburg, *First the Seed*, 66.

audiences to reexamine the pastoral understanding of agricultural practice and natural environment. As a result, the American journalists and editors who circulated the narrative of nature formulated under the influence of figures such as John Muir, Ralph Waldo Emerson or Henry David Thoreau, produced a particular discourse of scientific breeding that would reverberate in the media representations of genetically modified food crops as the century came to a close.

### 3.5 *Conclusion*

"The flowers and fruits of California are less wonderful than the flowers and fruits which Mr. Burbank has made".[362] With these words de Vries expressed his appreciation of the horticulturist's work during one of the many dinners he attended while visiting Northern California. De Vries's theory contributed to building a public culture of science which allowed the emergent discipline of genetics to receive recognition as a field that could potentially contribute to the growth of national economy. Facilitated by the widespread interest in plant modification conveyed in the enthusiastic press coverage of Luther Burbank's activities, the introduction of de Vries's mutation theory to California advanced a shift in the public communications about the American agricultural practice, foregrounding the vision of modern farming based on insights from scientific research into heredity. An analysis of the discursive strategies mobilized in the press representations of knowledge about the science of plant and animal heredity demonstrates that these communications had become embedded within the authoritative narrative of nature promoted by the Californian preservation movement.

Considered as an episode in the history of American science popularization, the case of de Vries's mutation theory shows the degree to which the public accommodation of scientific knowledge had been contingent upon different interests expressed by parties involved in

[362] Quoted in: William S. Harwood, *New Creations in Plant Life*, 364. Also see J. L. M., "Luther Burbank's Achievements in Plant-Breeding" *Scotsman* (27 Jun 1905): 9.

popularization activities. De Vries had developed his scientific agenda in a cultural context where practical applications of knowledge about plant heredity served to legitimate pure investigations into the evolutionary history of plants. By the time of his first visit to the United States, the botanist had already been internationally famous. The two volumes describing his work to English-speaking audiences, *Species and Varieties* and *Plant-Breeding*, only served to cement his fame as a scientific figure able to move between the worlds of academic science and commercial plant breeding. The American audiences, enveloped in the positivistic ideology of the Progressive Era, appreciated the emphasis on practice in communications about recent developments in biology. De Vries promoted practical applications of his theory of mutation – and so did the American mutationists, concentrated around research centers in Cold Spring Harbor or Tucson, and closely connected to private patrons such as the Carnegie Institution in Washington, later followed by the Rockefeller Foundation.

In combination with de Vries's interest in communicating the value of his theory, the American mutationists encouraged the public exposition of scientific breeding experiments as accessible to breeders without formal training. Inviting this type of lay knowledge construction, the mutationists negotiated a new space for previously non-legitimate knowledge produced by professional breeders employed at non-academic agricultural centers. To the American journalists and editors, the democratic character of the theory presented in two volumes of de Vries's Berkeley lectures offered an opportunity for covering and celebrating the practical implications of scientific breeding. Aligning the work of a well-known foreign academic scientist with the achievements of a local celebrity, Luther Burbank, the American press rendered scientific knowledge about heredity accessible to a wider audience and explicitly suggested that it was within reach of non-expert communities such as farmers, horticulturists, and breeders. The democratization of scientific knowledge about plant and animal heredity allowed the American editors to locate these early

genetic experiments within the interpretive framework of the American Progressivism. This characteristically entrepreneurial view of science would soon power the productive emergence of American genetics as a scientific discipline drawing on the rich history of practical research conducted by breeders working at state experiment stations and agricultural colleges scattered across the United States.

*Appendix 3.1*

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## Chapter 4

## Artificial Transmutation of the Gene: Hermann J. Muller's *Drosophila* Experiments and the American Science Journalism, 1927-1945

### 4.1 *Introduction*

"When some future historian contrasts our barbaric twentieth century with his own happy era he will not stint himself in praising Muller. 'To his monstrous fruit flies we trace the first deliberate, successful scientific interference with the processes of heredity by external agencies' he will say of the Texan professor". Such a prediction graced the pages of the *New York Times* in an article penned by Waldemar Kaempffert, a leading American science journalist of the interwar period.[363] Together with other science writers, Kaempffert erroneously depicted the geneticist Hermann J. Muller as the first scientist to ever produce an artificial variation of a living organism.[364] In the summer of 1927, Muller published a summary of his experimental findings in *Science* magazine under a sensational title "Artificial Transmutation of the Gene".[365] A few weeks later, the geneticist offered a detailed account of his work in a paper presented at the Fifth International Congress of Genetics in Berlin.[366] The *Science News-Letter* reported how Muller "stood up before a

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[363] Waldemar Kaempffert, "A Biologist's View of Man's Future" *New York Times* (15 Mar 1936): 4. For biographical information about Waldemar Kaempffert (sometimes referred to as Walter Kaempffert), see "Kaempffert the 'Vulgariser'" *New Scientist* 4 (13 Dec 1956): 6-7; "Waldemar Kaempffert Dies: Science Editor of The Times, 79" *New York Times* (28 Nov 1956): 35; "Kaempffert, Waldemar Bernhard," in *American Men of Science: A Biographical Directory*, Jaques Cattel (ed.), 9th ed., vol. 1, Lancaster, PA: The Science Press, 1955.

[364] For Muller's fame and legacy, see Luis Campos, *Radium and the Secret of Life*, Chicago: University of Chicago Press, 2015: 223-7.

[365] Hermann J. Muller, "Artificial Transmutation of the Gene" *Science* 66 (1927): 84-87.

[366] Ibid, "The Problem of Genetic Modification" *Proceedings of the 5th International Congress of Genetics*, Berlin, 1927: 234-60. For biographical information about Muller, see: Elof A. Carlson, *Genes, Radiation and Society: The Life and Work of H. J. Muller*, Ithaca: Cornell University Press, 1981. For more concise sources, see Elof A. Carlson, "Speaking Out About the Social Implications of Science: the Uneven Legacy of H. J. Muller" *Genetics* 187.1 (Jan 2011): 1-7; ibid, *Hermann Joseph Muller, 1890-1967*, Washington, DC: National Academy of Sciences, 2009; James Jamieson, "Hermann J. Muller: Nobel-Prize Winning Eugenicist" *Mankind Quarterly* 43.3 (Spring 2003): 291-304; Elof A. Carlson, "Eugenics and Basic Genetics in H.J. Muller's Approach to Human Genetics" *History and Philosophy of the Life Sciences* 9.1 (1987): 57-78; ibid, "H. J. Muller: The Role of the Scientist in Creating and Applying Knowledge" *Social Research* 51.3 (Fall 1984): 763-82.

distinguished audience at the International Genetics Congress at Berlin, and in the most unsensational language imaginable broke the news of one of the most sensational researches ever conducted in the whole field of biology".[367]

Exposing carefully designed fruit fly stocks to doses of x-ray radiation, Muller dramatically increased the frequency of lethal mutations and, as he believed, opened an avenue to advancing knowledge about the gene. "It is agreed on all sides at the gathering of scientific men that the past year has been one of revolution in the study of heredity among living things, comparable with 1859, when Darwin published *The Origin of Species*, and 1900, the year of the rediscovery of Mendel's law", wrote Watson Davis, the managing editor of a science news distribution agency, Science Service.[368] As Luis Campos persuasively argues in a recent study of radium in biological investigations, Muller had been aware of the prior attempts at producing artificial variations with chemical agents or radiation undertaken by mutationists such as Daniel T. MacDougal, Charles S. Gager, or Albert F. Blakeslee, as well as the recognized American geneticist, Thomas Hunt Morgan.[369] Following Jacques Loeb's mechanistic research agenda geared at producing a "technology of living substance", the second decade of the twentieth century intensified the experimental orientation in the American biology. According to Philip J. Pauly, Muller's scientific agenda which prompted his x-ray experimentation on the genotypes of the fruit fly, *Drosophila melanogaster*, realized the idea of "controlling life" which had originated in the geneticist's reading of Loeb.[370] Muller's experiments reflected an attitude which had been present among the American biologists since the dawn of the century, when the affinity between biology and physics had been expected to shape the future of the American life science.[371] This view prevailed during the interwar

[367] Frank Thone, "X-Rays Speed Up Evolution Over 1,000 Per Cent" *Science News-Letter* 12.340 (1927): 243-6.
[368] Watson Davis, "The Evolution Theory Entering New Phase" *Current History* 27.5 (1928): 707-12.
[369] Campos, *Radium and the Secret of Life*, 205-8. See also Staffan Müller-Wille and Christina Brandt (eds.), *Heredity Explored: Between Public Domain and Experimental Science, 1850-1930*, Cambridge, MA: MIT Press, 2016.
[370] Philip J. Pauly, *Controlling Life. Jacques Loeb and the Engineering Ideal in Biology*, New York: Oxford University Press, 1987: 177-8.
[371] For the compatibility of Hugo de Vries's mutation theory with physics, see Campos, *Radium and the Secret of Life*, 121-5 (for MacDougal); 135-44 (for Gager), 170-3 (for Blakeslee).

period. In a 1934 survey of recent "explorations along the biological frontier", the Rockefeller Foundation's chief science writer, George W. Gray, postulated that the "future of biology […] lies in experimentation. […] And the future of biological experimentation […] lies in the strange and mysterious ways of radiation".[372]

In a classic examination of evolutionary theories in the history of biology, Jan Sapp noted that the artificial production of mutations offered genetics "a new lease on life", as it provided the discipline "with one of its most important analytic devices and one of its most important sources of material for investigation".[373] As I have already indicated, science journalists who orchestrated the coverage of science and technology in prestigious nationwide publications such as the *New York Times* or the *Washington Post* presented sensationalized accounts of Muller's experiments. Their representations contributed to the formulation of Muller's legacy as the first scientist to ever alter an organism's genome. His experiments allowed for the quantitative scoring and determining rates of mutation that had far-reaching implications for the discipline of genetics, catapulting Muller into international fame within mere months after publishing his findings in *Science*, and eventually bringing him the Nobel Prize in 1946. In March 1928, he reportedly attracted a thousand-person audience composed of students, university staff, and the general public in a public lecture at a Texas college.[374] Soon after the publication of Muller's *Drosophila* experiments, the first sensational news of other mutations hit the press. The *Los Angeles Times* dedicated its first page to a story about William H. Dieffenbach's work with irradiated chicken eggs at the Flower Hospital in New York.[375]

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[372] George W. Gray, "Radiation and Life" *Harper's Monthly Magazine* 169.1010 (1 Jul 1934): 210-221; 221. In 1928, the National Research Council established a Committee on the Effects of Radiation on Living Organisms, see Helen A. Curry, *Evolution Made to Order. Plant Breeding and Technological Innovation in Twentieth-Century America*, Chicago: University of Chicago Press, 2016, Chapter 4; National Academy of Sciences, *The National Academy of Sciences: The First Hundred Years, 1863-1963*, Washington: National Academy of Science Printing and Publishing Office, 1978: 314.

[373] Jan Sapp, *Genesis: The Evolution of Biology*, Oxford: Oxford University Press, 2003: 141.

[374] "Muller Speaks Here Thursday to Over 1,000" *Campus Chat* 12.23 (24 Mar 1928): 1.

[375] For a biographical sketch of William H. Dieffenbach, see "William Dieffenbach," in Jonathan Davidson, *A Century of Homeopaths: Their Influence on Medicine and Health*, Durham: Springer, 2014: 102-4.

The editor of the piece designated the "control and understanding of life force itself" as the central goal of contemporary biology.[376]

By mid-1928, the American public had been exposed to numerous facts proving that "if the condition under which the genes interact are changed by external forces, such as X-rays, heat, light, or by chemicals, the genes can be juggled and new varieties of plants and animals created", as reported Waldemar Kaempffert.[377] Kaempffert continued: "If, even with our present meager knowledge and skill, a Muller can predict that with a given dosage of X-rays a wingless race of fruit flies shall be born, surely we are on the road toward controlling human evolution". Kaempffert had not been alone in extrapolating Muller's mutation research into human heredity (Figure 8); Muller himself had been prone to drawing such conclusions as he eagerly embedded his experiments in the authoritative discourse of human improvement, at the time shared by the rising discipline of genetics and the eugenic movement. As I shall demonstrate, Muller's artificial production of mutations did not generate far-reaching visions of agricultural improvement through scientific breeding which had previously accompanied the public representations of Hugo de Vries's mutation theory. Instead, the interwar era science journalists located that same potential for evolutionary control in a cultural current which represented humanity as biologically, socially, and morally unprepared for a reality characterized by unprecedented technological advancement.

[376] "Sex-Change Achieved" *Los Angeles Times* (1 May 1928): 1.
[377] Waldemar Kaempffert, "The Superman: Eugenics Sifted" *New York Times* (27 May 1928): 72.

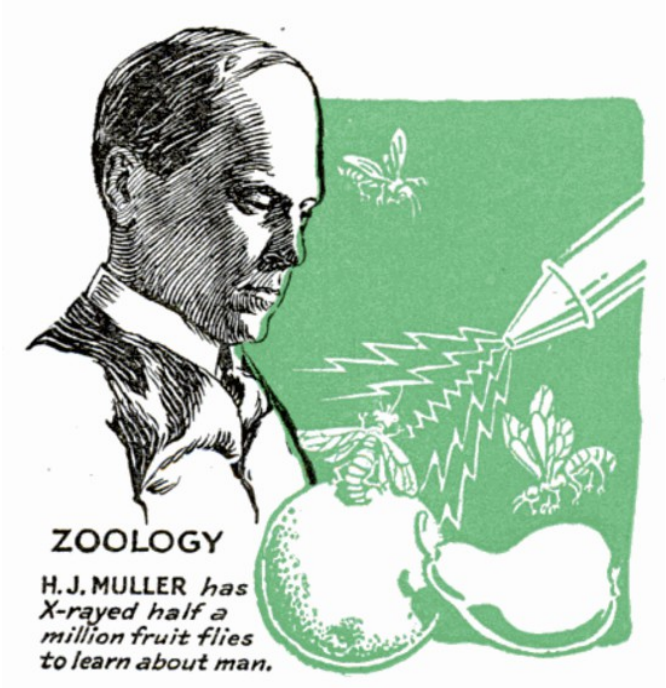


Fig 8. Visual representation of Muller's *Drosophila* experiments. Source: "Wonder Stories in the Making" *Popular Science Monthly* (Apr 1928): 50-1. Credits: Google-digitized.

Science journalists foregrounded the implications of Muller's *Drosophila* research for human societies and discussed its potential for controlling evolution in a context dominated by a discourse of science which emphasized its complementarity with religion. Consequently, they developed a particular language for describing these early attempts at genetic modification. Two features published by the *New York Times* in the spring of 1928 encapsulate the common tendencies of science writers to accommodate Muller's x-ray mutations in the public sphere.[378] Both articles drew an explicit link between Muller's research and cosmic rays, a type of natural radiation at the time examined by the principal spokesman for the American science and a scientific celebrity, Robert A. Millikan. Millikan had been capable of controlling the public image of his research by embedding it within the religious-scientific narrative which he championed. As the present chapter shall illustrate, the language employed by science writers to describe mutant *Drosophila* was

[378] "Altered Heredity of Flies by X-Ray" *New York Times* (25 Apr 1928): 15; "Cosmic Rays and Evolution" *New York Times* (26 Apr 1928): 26.

influenced by Millikan's religious narrative of science. Science journalists examined Muller's artificial mutations in a dialog with Millikan's natural cosmic rays, contrasting the prying "man made, laboratory" x-ray radiation with the natural – and often sacred – radiation types which unveiled the order of creation. Science writers described Muller's artificial mutagenesis by x-ray radiation as "shuffling cards in a pack", hinting at its arbitrary, and possibly dangerous character since it held power to "upset nature's plans". The public clash of the two different radiation types represented by two radically different scientific personalities captured in science journalism thus prompted the discursive transformation of the expression "mutation". While at the beginning of the twentieth century, mutation was popularly interpreted as a discontinuous evolutionary jump which generated an entirely new species, during the late 1920s the expression began to function as a synonym for physical deformation.

### 4.2 *Public Culture of Science During the Interwar Period*

"There is abundant evidence of a widened and deepened interest in modern science. How could it be otherwise when we think of the magnitude and the eventfulness of recent advances?", asked J. Arthur Thomson in the introduction to his bestselling work, *The Outline of Science.*[379] At the onset of the interwar period, the scientific profession emerged from the cultural isolation it experienced at the dawn of the century when research had been conducted behind the closed doors of laboratories funded by universities, philanthropists, or industrialists. Following the First World War, the American scientific community increasingly depended on funding granted by central administration agencies such as the National Research Council. In spite of the common mistrust placed by scientists in communicating their research to the public, motivated by the ever-present

[379] John Arthur Thomson, *The Outline of Science. A Plain Story Simply Told*, New York: G. P. Putnam, 1922: 3. The volume had been popular on both sides of the Atlantic, selling over 100,000 copies in the first five years on the American market, see Peter J. Bowler, *Science for All. The Popularization of Science in Early Twentieth-Century Britain*. Chicago: University of Chicago Press, 2009: 104-5.

press sensationalism, the demand placed on the scientific community to institutionalize accessible scientific education and align scientific research with broader cultural values spurred the revival of science popularization in the United States.[380]

Previously decentralized, the American scientific community now constructed the cultural value of its activity through the lens of a particular national ideology of science, perpetuated vigorously by figures such as Robert A. Millikan. As I shall demonstrate, the renowned physicist and celebrity scientist served as a principal actor in the accommodation of Hermann Muller's mutation research in the public sphere. This national ideology of science located pure scientific investigations as a factor mobilizing the social, technological, and moral progress of the society, while simultaneously preserving the values of liberal democracy.[381] It had been common for educated middle-class audiences and scientists to view science as cumulative and progressive. In their communications with the American public, still enveloped in the legacy of the Progressive movement, scientific communities emphasized the dependence of technology on pure science. Their collective public image equipped the American imagination with a new type of cultural hero; the scientist, best captured in Sinclair Lewis's *Arrowsmith*, a Pulitzer-winning novel serialized in the *Los Angeles Times* in 1926.[382] The demand for popular accounts of science rose dramatically, and scientific communities supplied the American audiences with popularizations in formats ranging from magazine features and newspaper articles to popular books and radio transmissions.

The widespread interest in scientific novelties generated a need for an agency that would be responsible for disseminating accurate science news. The year 1921 witnessed the establishment of

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[380] For history of American science popularization during the 1920-30s, see Marcel LaFollette, *Science on the Air: Popularizers and Personalities on Radio and Early Television*, Chicago: University of Chicago Press, 2008; Ibid, *Making Science Our Own. Public Images of Science 1910-1950*, Chicago: University of Chicago Press, 1990; John C. Burnham, *How Superstition Won and Science Lost. Popularizing Science and Health in the United States*, New Brunswick: Rutgers University Press, 1987; Ronald C. Tobey, *The American Ideology of National Science, 1919-1930*, Pittsburgh: University of Pittsburgh Press, 1971. See also Bowler, *Science for All*, 144-7; 186-7.

[381] Tobey, *The American Ideology*, 74-8.

[382] See Charles E. Rosenberg, *No Other Gods: On Science and American Social Thought*, Baltimore: The Johns Hopkins University Press, 1976, Chapter 7.

such an institution. A non-profit organization which grew out of the American Society for the Dissemination of Science, Science Service was founded and generously endowed by the newspaper mogul Edward W. Scripps.[383] Under the editorship of Edwin E. Slosson, a recognized science popularizer and author of the bestselling volume *Creative Chemistry*, Science Service distributed science news stories to newspapers all over the country and published its weekly periodical, *Science News-Letter*.[384] By the late 1920s, the Associated Press joined the quest for quality science stories by establishing a special service dedicated to science news and hiring two science writers. Scientific associations employed public relations officers and created specialized news outlets as well. The Rockefeller Foundation, for instance, hired a prominent science writer, George W. Gray, who contributed to a variety of publications ranging from prestigious newspapers to popular family magazines.[385]

The press reacted to this interest by ensuring that science coverage came from a brand new breed of writers, science journalists. Science journalists grouped under the National Association of Science Writers which, as John Burnham reported, grew from twelve members upon its foundation in 1934 to six hundred professionals in the 1960s.[386] The *New York Times* hired science writers and editors such as Alva Johnston or Waldemar Kaempffert, followed by Elias R. Sutton in the *Los Angeles Times* or John J. O'Neill in the *Brooklyn Eagle*.[387] Between 1923 and 1924, the *Washington Post* published J. Arthur Thomson's *The Outline of Science* as a weekly serial under the scientist's editorship. Watson Davis, the managing editor of Science Service and later editor of the *Science*

[383] For the history of Science Service, see Tobey, *The American Ideology*, Chapter 3; David J. Rhees, " A New Voice for Science: Science Service Under Edwin E Slosson, 1921-29", MA dissertation, University of North Carolina at Chapel Hill, 1979.

[384] For Slosson's approch toward science popularization, see Tobey, *The American Ideology*, 71-89; Rhees, "A New Voice for Science", Chapter 3.

[385] See LaFollette, *Making Science Our Own*, 19.

[386] Burnham, *How Superstition Won*, 176. For the history of science journalism, see George Robert Ehrhardt, "Descendants of Prometheus: Popular Science Writing in the United States, 1915-1948", PhD dissertation, Duke University, 1993.

[387] For biographical information about Elias (Eli) Ransom Sutton, see *The Michigan Alumnus*, vol 41, Ann Arbor: The Alumni Association of the University of Michigan, 1935: 128. For John J. O'Neill, see Elizabeth A. Brennan and Elizabeth C. Clarage "John Joseph O'Neill" *Who's Who of Pulitzer Prize Winners*, Phoenix: The Oryx Press, 1999: 560.

*News-Letter*, had been responsible for a daily science column in the *Washington Herald* as well. Prestigious nationwide publications listed above dedicated space to the coverage of scientific research and employed science writers to improve the quality of science reporting during the 1920s, a decade when the expansion of science and technology had seemed almost limitless.

"At one moment [a member of the general public] scorns the scientist for a highbrow, at another anathematizes him for blasphemously undermining his religion; but at the mention of a name like Edison he falls into a coma of veneration", wrote of the contemporary "capricious and varied" attitudes toward science the physicist and future Nobel laureate, Percy W. Bridgman.[388] Hermann Muller's experiments with *Drosophila* mutations hit the newsstands at a particular moment in the history of public attitudes toward science in the United States. During the 1920s, the press frequently offered representations of science as a challenge to the Christian doctrine; a conflict which had found generous articulation in the extensively covered 1925 Scopes trial, in particular the exchange between its principal actors, Charles Darrow and William J. Bryan.[389] In her comprehensive study of science stories in American magazines between 1910 and 1955, Marcel C. LaFollette indicated that during the second half of the 1920s, a third of lead articles about science examined scientific topics in relation to religion.[390]

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[388] Percy W. Bridgman "The New Vision of Science" *Harper's Monthly Magazine* 158.946 (1 Mar 1929): 443-51.

[389] For scholarship on the history and cultural impact of the Scopes trial, see Edward J. Larson, *Summer for the Gods. The Scopes Trial and America's Continuing Debate Over Science and Religion*, New York: Basic Books, 2006; ibid, "The Scopes Trial in History and Legend," in *When Science and Christianity Meet*, David C. Lindberg and Ronald L. Numbers (eds.), Chicago: University of Chicago Press, 2003: 245-64; Ronald L. Numbers, *Darwinism Comes to America*, Cambridge, MA: Harvard University Press, 1998; Peter J. Bowler, *Monkey Trials and Gorilla Sermons. Evolution and Christianity from Darwin to Intelligent Design*, Cambridge, MA: Harvard University Press, 2007; James Gilbert, *Redeeming Culture: American Religion in the Age of Science*, Chicago: University of Chicago Press, 1997, Chapter 2. For the history of anti-evolution movement in America, see Jeffrey P. Moran, *American Genesis: The Evolution Controversies from Scopes to Creation Science*, Oxford: Oxford University Press, 2012. For the relationship between the Scopes debate and its cultural context, see Constance A. Clark, "Evolution for John Doe: Pictures, the Public, and the Scopes Trial Debate" *Journal of American History* 87.4 (2000): 1275-303. For examples of such publications, see: Edwin Grant Conklin, "Bryan and Evolution. Why His Statements Are Erroneous and Misleading – Theology Amusing if Not Pathetic" *New York Times* (5 Mar 1922): 103; Bertram C. A. Windle, "Catholics and Darwin" *New York Times* (26 Mar 1922): 99.

[390] LaFollette, *Making Science Our Own*, 152.

"One of the valuable results of the Dayton affair is the stimulus it has given to the rational discussion of the various ideas, scientific, ultrascientific, and reactionary, concerning evolution", wrote David Starr Jordan, the retired president and chancellor of Stanford University who had served as an expert witness in the Scopes trial.[391] "Evolution is again an exciting word", remarked Vernon Kellog, noting the public engagement with the issue.[392] In the wake of the Scopes trial, the American public engaged with the question of evolution, frequently represented in the popular press in a theistic variant which emphasized its compatibility with the Christian doctrine.[393] As I shall demonstrate, media expositions of Muller's mutation experiments had been regulated by the public investment in the contrast between the reductionist biological investigations into evolution and the theistic visions of evolution which depicted it as a process demonstrating the order of God's creation.

### 4.3 *Muller's Mutations and Visions of Evolutionary Control*

In 1922, the *Century Magazine* published Albert E. Wiggam's "The New Decalogue of Science. An Open Letter from the Biologist to the Statesman". The pamphlet shortly became a national bestseller.[394] Drawing a vision of genetic determinism where "heredity, and not the environment, is the chief maker of men", Wiggam argued that "in the germ cell, from which every man is born, there are resident those mighty personal forces by which he can rise in well-nigh any environment, and, within the limits of human freedom, exclaim: 'I am the master of my fate, I am

[391] David Starr Jordan, "Evolution Discussed" *Los Angeles Times* (4 Jul 1926): 22.

[392] Vernon Kellogg, "What Evolution Stands For Now – The Changes Accepted Since Darwin's Time Are Presented by a Recognized Authority on the Subject" *New York Times* (21 Jun 1929): XX 1.

[393] See Constance A. Clark, *God–or Gorilla. Images of Evolution in the Jazz Age*, Baltimore: The Johns Hopkins University Press, 2008: 88-93. For resources illustrating the topic, see contributions that are part of "Part III: Science and Religion, Evolution and the Bible," in *Fundamentalism versus Modernism*, Eldred C. Vanderlaan (ed.), New York: H. W. Wilson, 1925. The section contains Robert Millikan's "Joint Statement upon the Relations of Science and Religion, by Religious Leaders and Scientists", called the Millikan Manifesto, see ibid, 294-6.

[394] Albert Edward Wiggam, "The New Decalogue of Science. An Open Letter from the Biologist to the Statesman" *Century Magazine* 103.5 (March 1922): 643-50. The article was republished as Albert Edward Wiggam, *The New Decalogue of Science*, Indianapolis: The Bobbs-Merrill Company, 1923.

the captain of my soul'".[395] In his concluding remarks, Wiggam quoted William E. Henley's 1888 poem entitled "Invictus" which within a decade would serve as a source text for another significant, even if less famous, biological vision formulated by Hermann J. Muller in *Out of the Night. A Biologist's View of the Future*, published in 1936 while the geneticist resided in Moscow. The slim volume delineated Muller's particular take on the idea of population-wide genetic control, serving as one example in an array of numerous theoretical works which hinted at opportunities presented by the application of biological principles to human societies.[396] In a review for the *New York Times*, Waldemar Kaempffert cautiously stated that Muller's vision is "something like a religion which has no God, which deals entirely with human destiny and which expects a new kind of sacrifice and reaps a new kind of joy".[397] Another reviewer suggested that Muller's speculative account would "shock the traditional type of person untrained in the scientific mode of reasoning"; the kind of reasoning Kaempffert called "without soul and heart".[398]

Muller's work found much appreciation among the British audiences which since the early 1920s had been exposed to a variety of biological speculation.[399] Between 1923 and 1931, London's Kegan Paul published a collection of texts contributed by British and American scientists to the visionary "To-day and To-morrow" series, quickly reprinted in the United States, which had offered perspectives on the scientific manipulation of human bodies and their reproductive functions.[400]

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395 Wiggam, *The New Decalogue of Science*, 42.

396 Hermann J. Muller, *Out of the Night. A Biologist's View of the Future*, London: Victor Collondz, 1936: 50. Muller sent a copy of *Out of the Night* to Joseph Stalin, see John Glad, "Hermann J. Muller's 1936 Letter to Stalin" *Mankind Quarterly* 43.3 (Spring 2003): 305-19.

397 Waldemar Kaempffert, "A Biologist's View of Man's Future" *New York Times* (15 Mar 1936): 4

398 Henry Flury, "Scientists" *Washington Post* (9 Aug 1936): 8.

399 The work sold in only 1,000 copies in the United States, in England, it had attracted the attention of the Left Wing Book Club and sold 13,000 copies, see Daniel J. Kevles, *In the Name of Eugenics: Genetics and the Uses of Human Heredity*, New York: Knopf, 1985: 190-1. For reviews, see L. T. Hites, *Religious Education* 31 (Jan 1936): 233-4; Julian Huxley "Marxist Eugenics" *Eugenics Review* 28.1 (Apr 1936): 66-8; Ray Erwin Baber, *American Sociological Review* 1.3. (Jun 1936): 533-4; A. J. Carlson, *American Journal of Sociology*, 42.1 (Jul 1936): 134-5. For the reception of Muller's work in the United States, see Peter J. Kuznick, *Beyond the Laboratory: Scientists as Political Activists in the 1930's America*, Chicago: University of Chicago Press, 1987: 123-6.

400 For works included in the series, see J. B. S. Haldane, *Deadalus, or Science and the Future*, New York: Dutton, 1924; Herbert S. Jennings, *Prometheus, or Biology and the Advancement of Man,* New York: Dutton, 1925; Ronald C. Macfie, *Metanthropos, or, the Body of the Future*, London: Kegan Paul, 1928; John D. Bernal, *The World, the Flesh and the Devil*, London: Kegan Paul, 1929.

During the same decade, the American audiences confronted a wave of books and pamphlets presenting visions of evolutionary control, reviewed in the national press under suggestive titles such as "Man, the Captain of His Fate", "Directing the Course of Our Own Evolution", or "Mankind Must Bring About a Biological Revolution".[401] In the introduction to his bestselling work, J. Arthur Thomson argued that contemporary investigations into evolution brought about "a promise of an increasing control—a promise that Man will become not only a more accurate student, but a more complete master of his world".[402] These works had set the tone for the reception of Muller's mutations.

The idea of controlling species evolution through scientific insight into heredity had appeared in the American public imagination at the dawn of the century when – as the previous chapter indicates – the popular expositions of Hugo de Vries's mutation theory promised the production of new plant varieties "at will" or "to order". In an obituary for the Dutch botanist, a *New York Times* writer positioned de Vries's mutation theory as the step initiating a new era in the experimental study of living organisms. "Out of his mutation doctrine", the writer argued, "came the discovery of genes by Morgan, the method of jarring them to bring forth new species and insects, and the still fantastic possibility of creating new plants and animals to order, and even of directing the course of man's evolution".[403] The American followers of Hugo de Vries had used the argument of species improvement for the national agriculture to gain professional authority, yet the first extrapolations of this claim to humans had appeared before the First World War as well, facilitated by the rise of mainline eugenics.[404] The sociopolitical movement of eugenics promoted

[401] Article titles come from the *New York Times* (15 May 1921): 44; Van Buren Thorne, *New York Times* (13 Jul 1924): 12; William MacDonald, *New York Times* (15 Feb 1925): 13. Examples of reviewed books include: Edwin Grant Conklin, *The Direction of Human Evolution*, New York: Charles Scribner's Sons, 1921; Vernon Lyman Kellogg, *Evolution*, New York: D. Appleton, 1924; Ellsworth Huntington, *The Character of Races as Influenced by Physical Environment: Natural Selection and Historical Development*, New York: Charles Scribner's Sons, 1924; Herbert Spencer Jennings, *The Biological Basis of Human Nature*, New York: W. W. Norton, 1930; Charles Chamberlain Hurst, *Heredity and the Ascent of Man*, New York: The Macmillan Company, 1935.

[402] Thomson, *The Outline of Science*, 4.

[403] "A Neo-Darwinian" *New York Times* (24 May 1935): 20.

[404] For examples of press representations on the topic, see "Man as His Own Creator" *Los Angeles Herald* (4 Feb 1906): 4; "Science to Make Men and Women Better" *Washington Post* (18 May 1906): 2; "Improve Human Race"

selective breeding as a solution to the well-articulated threat posed by carriers of unwanted traits to the quality of the American stock.[405] The American geneticists had initially aligned their work with the tenets of the movement to attract funding and raise the social status of their field.[406] Consequently, American genetics crystallized as a scientific discipline in constant dialog with eugenics. As the century progressed and the eugenic reform materialized in the successful implementation of sterilization and immigration laws across the country, numerous American geneticists refused to be further associated with the movement.[407]

Even if eugenics became rejected by the American geneticists and science journalists as based on questionable convictions about human heredity, in the public imagination of the 1920s and 1930s, genetics and eugenics shared a common discursive space for articulating fantasies about improving the human stock.[408] In a feature covering the core elements of the new "synthetic era" in the history of humankind, Waldemar Kaempffert placed the two disciplines side by side as offering solutions to the same problematic of social improvement. Acknowledging that "the remedy proposed by the eugenists for improving the social status of man is crude and brutal", Kaempffert presented Muller's discovery as a development that would enable biologists to participate in the

*Washington Post* (28 Oct 1906): 13; "To Improve the Human Race: Scientists Propose to Do for Man What Has Already Been Done to Plants and Animals" *Washington Post* (2 Feb 1908): 47.

405 For the history of eugenics in the United States, see Alexandra M. Stern, *Eugenic Nation. Faults and Frontiers of Better Breeding in Modern America*, Berkeley: University of California Press, 2005; Wendy Kline, *Building a Better Race: Gender, Sexuality, and Eugenics from the Turn of the Century to the Baby Boom*, Berkeley: University of California Press, 2001; Diane B. Paul, *Controlling Human Heredity: 1865 To the Present*, Atlantic Highlands, NJ: Humanities Press, 1995; Kevles, *In the Name of Eugenics*; Peter J. Bowler, *The Mendelian Revolution: The Emergence of Hereditarian Concepts in Modern Science and Society*, London: Athlone Press, 1989, Chapter 8. See also Mark A. Largent, *Breeding Contempt: The History of Coerced Sterilization in the United States*, New Brunswick, NJ: Rutgers University Press, 2008.

406 An example of this tendency was Thomas Hunt Morgan's careful approach toward eugenics, see Lily E. Kay, *The Molecular Vision of Life: Caltech, the Rockefeller Foundation, and the Rise of the New Biology*, New York: Oxford University Press, 1996: 82-5.

407 See Garland E. Allen, "Eugenics and Modern Biology: Critiques of Eugenics, 1910–1945" *Annals of Human Genetics* 75.3 (2011): 314-25; Kenneth Ludmerer, "American Geneticists and the Eugenic Movement, 1905-1935" *Journal of the History of Biology* 2.2 (1969): 337-62. See also Jonathan Harwood, "National Styles in Science: Genetics in Germany and the United States Between the World Wars" *Isis* 78.3 (1987): 390-414.

408 For examples of press criticism of the eugenic movement, see Waldemar Kaempffert, "The Superman: Eugenics Sifted" *New York Times* (27 May 1928): 72; Waldemar Kaempffert, "The Week in Science: Eugenists and Geneticists Are at Odds" *New York Times* (28 Aug 1932): 4 XX; Waldemar Kaempffert, "Genetic Principles" *New York Times* (25 Sep 1932): 17; Frank Zala, "Efforts at Eugenics Unscientific, He Says" *Washington Post* (4 Aug 1935): 5; Abraham Myerson, "Research Urged" *New York Times* (15 Mar 1936): 9; Waldemar Kaempffert, "The Week in Science: Theories of the Eugenists" *New York Times* (7 Jun 1936): 159.

improvement project productively. “By turning the X-rays on fruit flies the geneticist has played havoc with genes and chromosomes and produced species entirely new”, he wrote. Kaempffert instantly extrapolated Muller's experiments to the human species: “By similar mechanical interference, but more intelligent and more surely directed, the geneticist of the next century may create new men – beings who will be immune to tuberculosis, heart disease and the nervous breakdowns that wear us out”.[409]

Within a mere three months after the initial publication of Muller's findings, science journalists began to associate the experimental generation of *Drosophila* mutations with the question of evolutionary control of human organisms and societies. The high public status of genetics contributed to the appearance of this interpretation in the American press. Between the two World Wars, Americans were continually exposed to the promise the prestigious discipline of genetics held for understanding human heredity and developing tools that would permit evolutionary control.[410] In 1933, the *Los Angeles Times* and the *Washington Post* covered the annual spring meeting of the National Academy of Sciences, foregrounding a statement made by the esteemed geneticist, Thomas Hunt Morgan, about the relation of genetics to evolution and the discipline's potential for controlling the evolution of the human species.[411] Another factor which contributed to the widespread emphasis on the potential direction of human evolution presented by Muller's experiments were the geneticist's particular political views. Muller's radicalism and critical stance toward mainline eugenics served as a canvas for the accommodation of his artificial mutations among the American audiences.[412] Muller's investment in reform eugenics and readiness

[409] Waldemar Kaempffert, “Man Outdoes Nature in a Synthetic Era” *New York Times* (10 Aug 1930): 1 XX.

[410] For examples of such press coverage, see “Man, the Captain of His Fate” *New York Times* (15 May 1921): 44; Van Buren Thorn, “Directing the Course of Our Own Evolution” *New York Times* (13 July 1924): 12; William MacDonald, “Mankind Must Bring About a Biological Revolution” *New York Times* (15 Feb 1925): 13

[411] “Evolution's Basic Causes Pushed as Main Science Aim” *Washington Post* (25 Apr 1933): 18; “Energy Traced to Cosmic Rays” *Los Angeles Times* (26 Apr 1933): 7.

[412] Muller articulated his stance toward American eugenics in a speech delivered at the Third International Congress of Eugenics, see Hermann J. Muller “The Dominance of Economics Over Eugenics” *A Decade of Progress in Eugenics. Scientific Papers of the Third International Congress of Eugenics*, Baltimore: Williams & Wilkins, 1934: 138-44. The speech was later reported at length, see “Holds Capitalism Bars Eugenic Goal” *The New York Times* (24 Aug 1932): 8. For Muller's eugenic views, see Carlson, *Genes, Radiation, and Society*, Chapter 4; Diane B.

to bridge the theoretical gap between *Drosophila* and human genetics lead him to frequent speculations about the role of genetics in social development. He wholeheartedly believed that the "conscious control of human biological evolution" he understood as "the control by man of the hereditary material lying at the basis of life in man himself", would allow societies to limit the degree of biological disorganization consequent to the gradual accumulation of non-adaptive mutations; a concept he would later call the "mutation load".[413]

"Man should be able to improve vastly upon nature's results now that he knows more about the ways of the gene", declared Muller in an interview for the *New York Times*, speaking of the experiments conducted at the Department of Mutation and the Gene at the Academy of Sciences of the U. S. S. R. where the geneticist had resided between 1932 and 1936.[414] Muller's eugenic leanings had emerged already during his graduate training in the competitive environment of Thomas Hunt Morgan's fly room at the Columbia University.[415] In 1910, he connected the potential for controlling natural processes with the regulation of human heredity and species improvement before a student discussion club: "With knowledge of the laws of nature comes power to manipulate them, and knowledge of life thus means the perfection of man".[416] Upon the geneticist's relocation to the Rice Institute, the institution's president, Edgar O. Lovett, asked Muller to deliver a series of public lectures. In one such lecture, Muller designated the "central problem of biological evolution" to be the understanding and control of mutagenesis, which he suggested "might obviously place the process of evolution in our hands".[417] In a letter to Charles B. Davenport, Muller wrote: "I have never been interested in genetics purely as an abstraction, but always because of its fundamental

Paul, "'Our Load of Mutations' Revisited" *Journal of the History of Biology* 20.3 (1987): 321-35.

413 Glad, "Hermann J. Muller's 1936 Letter", 307. For Muller's concept of the mutation load, see Hermann J. Muller, "Our Load of Mutations" *American Journal of Human Genetics* 2.2 (1950): 111-76.

414 "Scientist Creates New Forms of Life" *New York Times* (29 Mar 1936): 29.

415 For the history of Thomas Hunt Morgan's group of geneticists, see James Schwartz, *In Pursuit of the Gene: From Darwin to DNA*, Cambridge, MA: Harvard University Press, 2008, Chapter 10; Robert E. Kohler, *Lords of the Fly: Drosophila Genetics and the Experimental Life*, Chicago: University of Chicago Press, 1994; Garland E. Allen, *Thomas Hunt Morgan: The Man and His Science*, Princeton: Princeton University Press, 1978.

416 Hermann J. Muller, "Revelations of Biology and Their Significance", qtd. in Carlson, *Genes, Radiation and Society*, 35.

417 Hermann J. Muller, "Applications and Prospects", qtd. in Carlson, *Genes, Radiation and Society*, 104-5.

relation to man–his characteristics and means of self-betterment, which constituted the primary source of my interest".[418]

In a classic study of the history of eugenics, Daniel J. Kevles pointed out that the American eugenic movement brought together members of conservative, progressive, and radical political outlooks.[419] Similarly to recognized scientists such as J. B. S. Haldane or Julian Huxley, Muller combined his socialist leanings with the idea of a scientifically planned society; a vision which found its fullest articulation in his theoretical work *Out of the Night*.[420] Ronald Tobey noted in his study of the national ideology of science in the early twentieth-century United States that the Darwinian depiction of nature in constant flux contributed to the formation of a philosophical basis for social reform.[421] Evolutionary notions had already lent themselves to the American socialists who at the dawn of the century referred to Hugo de Vries's mutation theory in arguments based on analogies drawn between evolutionary and social transformations. If a new species could arise within the period of one generation, as de Vries had suggested, so could new societies emerge through sudden revolutions.[422]

Contrary to the public imagination surrounding de Vries's *Oenothera* mutations, Muller's x-ray experiments did not inspire visions which emphasized the potential benefits to plant and animal breeders, even though Muller had mentioned such practical applications in the very first publication of his experimental results in *Science* magazine. Shortly after, the geneticist spoke in similar terms about his work at the meeting of the American Association for the Advancement of Science. If plant and animal organisms were found to tolerate doses of x-ray radiation required for producing

418 Qtd. in Ludmerer, "American Geneticists", 340.

419 Kevles, *In the Name of Eugenics*, 64.

420 See Kuznick, *Beyond the Laboratory*, Chapter 4; Diane B. Paul, "Eugenics and the Left" *Journal of the History of Ideas* 45.4 (Oct-Dec 1984): 567-590; Gary Werskey, *The Visible College: Scientists and Socialists in the 1930's*, New York: Holt, 1979. For Muller's engagement with socialism, see Kuznick, *Beyond the Laboratory*, 119-25.

421 Tobey, *The American Ideology*, 14.

422 See Diane B. Paul, *The Politics of Heredity: Essays on Eugenics, Biomedicine, and the Nature-Nurture Debate*, Albany: State University of New York Press, 1998; Jörg T. Richter, "The Fate of Mutation: Shift, Spread, and Disjunction in a Conceptual Trajectory" *Contributions to the History of Concepts* 6.2 (2011): 85-104; 96-7. For examples of such writings, see George Cotkin, "The Socialist Popularization of Science in America, 1901 to the First World War" *History of Education Quarterly* 24.2 (1984): 201-14.

permanent hereditary changes, Muller argued, "the method should become a practicable one for the use of breeders".[423] Comparing the impact of x-ray on genes to "a shotgun fired into a pile of pebbles", local Texan publications initially pointed to the economic significance of Muller's *Drosophila* mutations. While some editors of these local newspapers imagined a boost in cotton crop production, others envisioned the transformation of destructive insect species into harmless organisms.[424] No such visions could be found in representations produced by science journalists who shaped the public image of Muller's experiments and genetics by pursuing a radically different avenue in their coverage. Only the early reports of Muller's *Drosophila* mutations mentioned the potential value of these findings to the American agriculture, and they did so in passing. The vast majority of accounts presenting the geneticist's work foregrounded its potential application in controlling human evolution and improving the American stock.[425] The degree of investment science journalists located in the fantasy of humanity's scientific improvement is particularly striking when contrasted with the minimal press coverage dedicated to the concurrent x-ray work of the geneticist Lewis J. Stadler.[426] The x-ray irradiation experiments on the cultivated tobacco plant conducted by Thomas H. Goodspeed and Alex Olson did not receive substantial coverage in nationwide newspapers either.[427] Stadler's production of maize and barley mutations would have easily lent itself to the prewar Progressive rhetoric which had allowed de Vries's mutation research to thrive in the public sphere. However, this had not been the case during the interwar period.

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[423] Watson Davis, "The Evolution Theory", 708. For other examples of Muller's interest in the application of his findings to agricultural breeding, see Curry, *Evolution Made to Order*, 43.

[424] "University Man Plans to Speed Up Cotton Crops" *Borger Daily Herald* 1.293 (1 Nov 1927): 1; "Evolution May Be Witnessed Within Period of One Person's Observation" *Breckenridge Daily American* 8.103 (4 Nov 1927): 5; "Texan Gets Honors" *Abilene Times* 2.68 (5 Jan 1928): 4; "Rice Faculty in Who's Who" *Thresher* 13.14 (13 Jan 1928): 2.

[425] "X-Ray Perils" *Los Angeles Times* (21 Sep 1927): 4; "Speeds Breeding Types" *Los Angeles Times* (2 Oct 1927): 6.

[426] Muller published his findings a few months before Stadler. For Stadler's publications, see Lewis J. Stadler, "Genetic Effects of X-Rays in Maize" *Proceedings of the National Academy of Sciences* 14.1 (1928): 69-75; ibid, "Mutations in Barley Induced by X-Rays and Radium" *Science* 68.1756 (1928): 186-7. For scholarship on Stadler's work, see Curry, *Evolution Made to Order*, 30-55; Helen A. Curry, "Speeding Up Evolution: X-Rays and Plant Breeding in the United States," in *New Perspectives on the History of Life Sciences and Agriculture*, Denise Philips and Sharon Kingsland (eds.), Cham: Springer, 2015.

[427] For Goodspeed and Olson's work, see Curry, *Evolution Made to Order*, 35-48.

Why did the American science journalists choose to focus on the problem of biological and social improvement of human societies in their coverage of recent development in genetics? During the interwar period, representations of experimental genetic investigations had become embedded in the era's anxieties regarding humanity's status against the scientific and technological progress. Similarly to Bertrand Russell, Raymond B. Fosdick, a trustee and later president of the Rockefeller Foundation, questioned whether human societies are prepared to face the reality they had created. "Humanity stands today in a position of unique peril. An unanswered question is written across the future", he wrote, and proceeded: "Is man to be the master of the civilization he has created, or is he to be its victim? Can he control the forces which he himself has let loose? Will this intricate machinery which he has built up and this vast body of knowledge which he has appropriated be the servant of the race, or will it be a Frankenstein monster that will slay its own maker?".[428] Even if science and technology granted humanity a greater degree of control over the environment, modern life seemed to present new challenges to the collective health of the human stock. Science journalists engaged with this problem on numerous occasions, especially in features which contrasted the flawed contemporary social and biological reality with the rationally organized world of the future.[429]

[428] Raymond B. Fosdick, *The Old Savage in the New Civilization*, New York: Doubleday, Doran, 1928: 21.

[429] For a sample of this discourse, see Waldemar Kaempffert, "Lo! The Chemical Revolution" *New York Times* (11 Mar 1928): 74; Ransome Sutton, "Will a Machine Get Your Job?" *Los Angeles Times* (6 Nov 1932): 8; Waldemar Kaempffert, "Can Man Live in the World He Has Created?" *New York Times* (14 Feb 1937): 126; ibid, "Science, Invention and Society" *Social Studies* 28.5 (1937): 197-201.

# MUSEUM WILL DEPICT UPWARD CLIMB OF MAN

## In Chicago a Permanent Exhibition, Made Possible by the Gift of Mr. Rosenwald, Will Trace the Technical Progress of Humanity From the Earliest Inventions to the Wonders of Our Own Age

By WALDEMAR KAEMPFFERT,
Director of the Museum of Science and Industry of Chicago.

CHICAGO is erecting a museum of a type new in America and in some respects new in the world—a museum which will trace the technical ascent of man and reveal him inventing tools and machines, creating an artificial environment for himself, and evolving into a twentieth century scientist and engineer who controls the forces of nature.

The Museum of Science and Industry is the name of this institution. Walk through the thousands of exhibits that are now being built and assembled from all parts of the world and you walk through five hundred centuries—walk from a remote period when man's chief instrument was a stone hatchet and his chief chemical aid was fire to a time when an engineer on an ocean liner with a slight movement of the arm and hand sets 50,000 horsepower at work to drive through the Atlantic a hull that displaces 50,000 tons and that carries 5,000 souls.

That museum will pulsate with life. It will, therefore, bear about the same relation to ordinary museums that a collection of stuffed animals bears to a zoo. Machines will move. Moreover, you will make them move by pushing the buttons or pulling the levers that control the driving energy. For a romantic moment you will imagine that you are Lindbergh as you seat yourself in an airplane, start and stop the engine, and operate ailerons and rudders; or Edison as you perform the very experiments day is now properly and atmospherically placed in period rooms in which Miles Standish or Peter Stuyvesant would have felt at home.

Who it was that first introduced this new note into the museum it is impossible to determine. In technical museums it seems first to have been struck by the Science Museum of South Kensington. About twenty-five years ago that institution began to animate itself. It was packed with dead machines. All at once some of them began to move. The effect on the public was unmistakable. No public institution in London valves may be seen ceaselessly opening and closing to reveal the ever-fresh mystery of energy doing the engineer's bidding. Everywhere there are push-buttons, crank-handles and levers that you may manipulate and thus start machines yourself.

Here is a cabinet in front of which hangs a curtain. Step inside. Press the button at your left and hold your other hand before the white screen in front of you. There is a crackling as an X-ray tube is energized. You see the bones of your fingers silhouetted against the screen.

steam engine. A new age dawns before your eyes. What economists call the "industrial revolution" is brought about. Man receives a powerful impetus in his technical ascent. Factories spring up everywhere. Power spins, weaves, hammers, draws, bends and twists. A man does the work of a hundred men with only a single engine at his command. Coal becomes a priceless possession. Nations henceforth are willing to fight for it. For it means energy, cheap goods, a surer command of dead, resistant matter, national wealth, domination of world

You look out of the window and see the skyscrapers of Chicago.

Similarly in two minutes you walk through five centuries of streets. First there is the filth of Elizabethan London through which a gentleman must be carried in a chair, lighted on his way by link boys. Then street lights appear. The pavement is improving. Gas comes and sewers and water mains. Finally you step into Broadway, a blaze of light, with the pavement below honeycombed to provide conduits for pipes and electric cables that carry energy and living messages of millions of human

of man's technical ascent in the Museum of Science and Industry. You also place him where he belongs socially. He proves to be far more than Plato's tool-using animal. With energy at his beck and call he is shown transforming the world, and fashioning a new civilization. So, in this new type of museum, it is man and not the machine that is all-important; for the machine is but the molder of human society.

We are but vaguely conscious how inventions have changed civilization and the face of the earth. Take the elevator, for example.

stand and hang by a strap. The crowds cannot be shown in the model, more's the pity; but a daylight motion-picture projector can show them.

It is not always a pleasant picture of man's technical ascent that the museum will present. Much stupidity, cruelty, and injustice manifest themselves as machine after machine appears and new discoveries are applied. Whitney invents the cotton gin. The museum shows it. But it also shows what happened when it was introduced. The South is transformed. Cotton becomes of

trying for decades, at last successfully, to produce a vacuum. The practical mine-pump is the outcome. Watt is called upon to repair a model of one for the University of Glasgow. He sees how wasteful it is to condense the steam in the cylinder to produce a vacuum. He invents the separate condenser and makes the pump a real steam engine.

But he needs something to make a full-sized engine—a tool, a lathe, something that can bore out a cylinder with fair accuracy, so that steam will not leak past the piston. Beside the museum's Watt engine stands a huge panel with pictures on it. Above is the heading in large letters, "Causative Factors." There Watt's indebtedness to his inventive predecessors is set forth—his immediate technical heritage, the means for producing a vacuum by condensing steam, the old pump of Newcomen and Savery, and the lathe.

### Peering Into the Future.

In such a museum we peer even into the future. That future is dominated by electrical energy—so much is clear. Energy is no longer localized by coal. It is shot hither and thither along wires and sent rippling into space. The museum shows us in a transition period. No longer is it necessary to build factories in crowded centres because they are reasonably near coal mines. Statistics already indicate that they are moving out into the country where electrical energy is at hand, derived from some waterfall a hundred or more miles away and where labor is fairly abundant. Is the congested metropolis demands. The visitor to

Photograph from Field Museum of Natural History.

"The Pageant of Man's Technical Ascent" Will Be Shown in the Museum of Science and Industry. It Will Be Housed in Jackson Park, and Will Be an Exact Reproduction in Stone of the Old Fine Arts Building.

Fig 9. Waldemar Kaempffert, "Museum Will Depict Upward Climb of Man" *New York Times* (21 Jul 1929): 116. Credits: https://search.proquest.com/docview/104944018?accountid=9652.

A science that would enable human societies to control their evolution drew the attention of science journalists because it spurred the progressive narrative of science which was in demand. This narrative had been endorsed by Waldemar Kaempffert who in 1928 started his tenure as the director of Chicago's newly-established Museum of Science and Industry, which for the journalist stood to represent "the technical ascent of man and reveal him inventing tools and machines, creating an artificial environment for himself, and evolving into a twentieth century scientist and

engineer who controls the forces of nature" (Figure 9).[430] For science journalists who orchestrated the expositions of Muller's experimental production of mutations to the American educated middle classes, the promise it held for human societies in becoming true "masters of their fate" incontestably outweighed its potential advantages to the national agriculture.

### 4.4 *Cosmic Rays and Evolution – Laboratory vs. Nature*

In the summer of 1932, the American press reported a decisive event in the history of genetics, the Sixth International Congress of Genetics which took place in Ithaca, New York. In a special feature to the *New York Times*, the science journalist William Laurence reported Thomas Hunt Morgan's presidential address in which he traced the discipline's history. According to Laurence, Morgan's statement posed an open challenge to "the tendency of modern scientists in the fields of physics and genetics to introduce a non-deterministic, mystical element in the workings of nature".[431] Morgan's mechanistic view of life sciences extended to genetics, as he argued: "I think we can not overemphasize the significance of this relation between the theoretical side of genetics and the factual side as observed in the known behavior of the material basis of heredity". "To put the matter bluntly", he continued, "the recognition that there is a mechanism to which genetic theory must conform, if it is to be productive, serves to keep us on the right track and acts as a check to irresponsible speculation, however attractive it may seem in print".[432]

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[430] Waldemar Kaempffert, "Museum Will Depict Upward Climb of Man" *New York Times* (21 Jul 1929): 116. See also Waldemar Kaempffert, *From Caveman to Engineer. The Museum of Science and Industry*, Chicago: The Museum of Science and Industry, 1933.

[431] William Laurence, "Evolution Declared a Chemical Process" *New York Times* (26 Aug 1932): 19; ibid, "Evolution Process is Aided by X-Rays" *New York Times* (27 Aug 1932): 3.

[432] Thomas Hunt Morgan, "The Rise of Genetics," in *Proceedings of the Sixth international Congress of Genetics*, Donald F. Jones (ed), Vol.1, Austin: University of Texas Printing Division, 1968: 92. For details of Morgan's argument, see Garland Allen, "The Transformation of a Science: Thomas Hunt Morgan and the Emergence of a New American Biology," in *Organization of Knowledge in Modern America, 1860-1920*, Alexandra Oleson and John Voss (eds.), Baltimore: Johns Hopkins University Press, 1979: 123-210.

Even though Morgan did not mention any names, Laurence offered his readers a selection of the likely candidates who at the time did entertain such "irresponsible speculation". Among them was Henry Fairfield Osborn, director of the American Museum of Natural History in New York, and an influential figure in the American public life. During the 1920s, Osborn enjoyed the authoritative status of the foremost popularizer and defendant of evolution.[433] In connecting Osborn to the "mystical element" present in the contemporary biological research, Laurence referred to Osborn's dense and puzzling work illustrating his "Energy conception of Evolution and an energy concept of Heredity" which aimed, in the words of the author, to position the study of heredity "away from the matter and form conceptions which have prevailed for over a century".[434] Even if criticized by the members of the American scientific community, Osborn's progressive and teleological view of evolution figured as one example among numerous other metaphysical interpretations of heredity circulating in the public sphere during the 1920s.

One such representation connected biological evolution to the phenomenon of cosmic rays, at the time regarded as space radiations which could potentially generate variation among the living organisms on the Earth. Cosmic rays became a popular topic among the American audiences of the 1920s thanks to the scientific figure responsible for communicating the state of research to the public: Robert A. Millikan, a recognized experimental physicist, Nobel Prize winner, and celebrity scientist, who situated cosmic rays in the strong religious-scientific current which he personally championed.[435] Millikan studied cosmic rays while serving as the director of the California Institute

[433] Clark, *God–or Gorilla*, 18-5. For biographical information about Henry Fairfield Osborn, see Brian Regal, *Henry Fairfield Osborn: Race and the Search for the Origins of Man*, Burlington: Ashgate, 2002; Ronald Rainger, *An Agenda for Antiquity: Henry Fairfield Osborn and Vertebrate Paleontology at the American Museum of Natural History, 1890-1935*, Tuscaloosa: University of Alabama Press, 1991.

[434] Henry Fairfield Osborn, *The Origin and Evolution of Life: On the Theory of Action, Reaction and Interaction of Energy*, New York: Charles Scribner's Sons, 1925: vii.

[435] For biographical information on Millikan, see Robert Kargon, *The Rise of Robert Millikan: Portrait of a Life in American Science*, Ithaca: Cornell University Press, 1982; Daniel J. Kevles, "Robert Andrews Millikan," in *The Dictionary of Scientific Biograph*y, New York: Charles Scribner's Sons, 1974: 395-400; ibid, "Millikan: Spokesman for Science in the Twenties" *Engineering and Science* 32 (Apr 1969): 17-22; L. A. Du Bridge and Paul A. Epstein "Robert Andrews Millikan, 1868-1953: A Biographical Memoir," in *Biographical Memoirs of the National Academy of Sciences* 33, Washington, DC: National Academy of Sciences, 1959: 240-82; H. V. Neher "Millikan – Teacher and Friend" *American Journal of Physics* 32.11 (1964): 868-77. For Millikan's autobiography, see: Robert

of Technology where he conducted balloon and penetration experiments to determine the origin, frequency, power, and discharge rates of these radiations.[436] The significant investment in building a public image for his work and for the entire American national science rendered him an early example of Rae Goodall's "visible scientists".[437] He had been well-known to the public as a spokesman for the American scientific community and charming public educator whose science lectures reached millions of Americans through radio broadcasting technologies.[438] According to Marcel LaFollette's estimation, between 1920 and 1926 Millikan contributed one-sixth of all science articles published in *Scribner's Magazine*.[439] A few months before Muller unveiled his experimental findings, Millikan graced the cover of the *Time* magazine. Millikan's colleagues ridiculed the physicist's insistence on popularization, going so far as to define a milli-kan, measuring "one thousandth of a unit of publicity".[440] More of a businessman than scientist, Millikan boasted a "friendly and sociable temperament" which gained him numerous allies among the political and scientific elites in the United States.[441]

Together with the biologist Edwin Grant Conklin and geologist Kirtley Mather, Millikan represented a particular tendency in the American science popularization tied to the science and religion debate which – as I have already indicated – engaged the American audiences during the 1920s and culminated in the sensational Scopes trial. Born into a deeply religious family, Millikan received his education at Oberlin College where the faculty promoted the complementarity of science and religion. A similar perspective had been advanced in the public sphere by Harry

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A. Millikan, *The Autobiography of Robert A. Millikan*, New York: Prentice-Hall, 1950.

436 Tobey, *The American Ideology*, 140-6. For a summary of Millikan's cosmic ray research, see: Du Bridge and Epstein "Robert Andrews Millikan", 263-8.

437 Rae Goodell, *The Visible Scientists*, Boston: Little, Brown, 1977.

438 For Millikan's radio popularizations, see Marcel LaFollette, *Science on the Air: Popularizers and Personalities on Radio and Early Television*, Chicago: University of Chicago Press, 2008, Chapter 6.

439 LaFollette, *Making Science Our Own*, 33

440 Daniel J. Kevles, "Robert A. Millikan" *Scientific American* 240 (1979): 150.

441 LaFollette, *Making Science Our Own*, 63-4; Kevles, "Millikan: Spokesman for Science", 17. For an example of a press article describing Millikan as a modern scientist and businessman, see S. J. Woolf "Eternal Truth as a Scientist Sees It" *The New York Times* (9 Dec 1928): 2. For Millikan's personal traits, see Du Bridge and Epstein "Robert Andrews Millikan", 251.

Emerson Fosdick or Henry Drummond; both Modernist theologians whom Millikan endorsed in his public lectures and popular writings.[442] Millikan's popularization agenda had been shaped by a religious spin on the national ideology of science which reinforced the idea of a scientific basis for social progress that had suffered under the cultural impact of contemporary theoretical physics.[443] At times, Millikan went as far in his speculations as to suggest that "the future progress of mankind will bear some intimate relation to the future circulation of the Bible", as reported in the *New York Times*.[444] He formulated what would become a widespread interpretation of cosmic rays with the intention to "banish forever the nihilistic doctrine of [the universe's] ultimate heat death", as he declared.[445]

For Millikan, each cosmic ray corresponded "to the birth of an atom at some time in the evolution of creation".[446] Millikan's interpretation of cosmic rays demonstrated that "the process of creation is now going on in the heavens and that the earth, instead of being a disintegrating world as has long been believed is a changing, continuously evolving one". This assertion landed on the first page of the *New York Times* and *Los Angeles Times* merely a few months following the news about Muller's experimental findings. Waldemar Kaempffert shortly followed with an extensive feature article entitled "Super X-Rays Reveal the Secret of Creation", published in the widely-circulated Sunday edition of the *New York Times*.[447] Public expositions of cosmic rays represented the radiation as a "Scientific Proof of God", or a "mighty token of Creation's workshop".[448] According

[442] For Millikan's engagement in the science and religion debate, see Edward B. Davis "Robert Andrews Millikan: Religion, Science and Modernity," in *Eminent Lives in Twentieth-Century Science and Religion*, Nicolas A. Rupke (ed.), Frankfurt: Peter Lang, 2009: 253-74. For examples of Millikan's writings on the topic, see Robert A. Millikan, *Science and Life*, Boston: The Pilgrim Press, 1924, Chapter 3; ibid, *Evolution in Science and Religion*, The Terry Lectures Series, New Haven: Yale University Press, 1927.

[443] Tobey, *The American Ideology*, 137-49.

[444] "Dr. Millikan Links Circulation of Bible With 'the Future Progress of Mankind'" *New York Times* (7 Oct 1935): 4.

[445] Robert Millikan, qtd. in Edward B. Davis "Robert Andrews Millikan", 270.

[446] "Millikan Sees Rays as Clue to Creation" *New York Times* (21 Nov 1929): 26.

[447] "World Yet in Creation, Dr. Millikan Announces' *Los Angeles Times* (17 Mar 1928): 1; "Creation Continues, Millikan's Theory" *New York Times* (18 Mar 1928): 1; Waldemar Kaempffert, "Super X-Rays Reveal the Secret of Creation" *New York Times* (25 Mar 1928): 143.

[448] For examples of coverage representing cosmic rays through the religious lens, see Harry Carr "The Lancer" *Los Angeles Times* (12 Nov 1925): 1; "Sermons on Literature" *Los Angeles Times* (28 Apr 1928): 19; Bailey Millard "Scientific Proof of God" *Los Angeles Times* (7 Apr 1929): 4. Cosmic rays inspired a Methodist minister Lewis

to Millikan, Darwin's evolutionary theory strengthened the theological doctrine of immanence, as he asserted in his 1930 presidential address before the American Society for the Advancement of Science, published in the *New York Times*.[449] Millikan's religious interpretation of evolution in the context of cosmic rays relied on the rich history in associating cosmic and organic evolution traced by Luis Campos in a recent study of radium usage in twentieth-century experimental biology.[450] Millikan's representations resonated with the American audiences during the early Depression-Era; the editors of the *New York Times* asserted that nothing could affect "the cosmic optimism of the science that not only has such practical application, but has a faith in a continuing creation and that cooperates with 'a Creator continually on the job'".[451] Endorsed by another cosmic ray investigator, Arthur H. Compton, as "evidence for an intelligent power working in the world which science offers", the popularity of cosmic rays enveloped in the scientific-religious discourse began to wean together with Millikan's fame as the Depression Era advanced.[452]

Science journalists instantly connected Muller's mutation research with the study of cosmic rays, often confusing the two phenomena with one another. One scientist's statement that his work had been inspired by Muller's experiments "with the effect of cosmic rays on the procreative nature of fruit flies" went unnoticed by the editorial staff of the *New York Times*.[453] This alignment, founded on the supposed mutagenic properties of cosmic and x-ray radiation, had originated with Muller himself. Not even a year passed from his discovery when the geneticist delivered an address to the National Academy of Sciences, in which he explicitly connected his mutation research to findings about the cosmic rays and presented a hypothesis regarding the potential impact of natural

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Thurber Guild to follow his popular work *The Romance of Religion* with one entitled *Cosmic Ray in Literature*, where he explicitly, and mistakenly alluded to Millikan's discovery of cosmic rays, see "Sermons on Literature" *Los Angeles Times* (28 Apr 1928): 19. Cosmic rays were discovered by a Nobel laureate in physics, Victor Francis Hess.

449 "Text of Millikan's Address on Origin and Destiny of Matter" *The New York Times* (30 Dec 1930): 12.

450 Campos, *Radium and the Secret of Life*, 16-9.

451 "Cosmic Optimism" *New York Times* (31 Dec 1930): 16.

452 Kevles, "Millikan: Spokesman for Science", 22.

453 "Says X-Rayed Eggs Hatch Mostly Hens" *New York Times* (1 May 1928): 25. The same news had been reported correctly by *The Los Angeles Times* and *The Washington Post*, see "Sex-Change Achieved" *Los Angeles Times* (1 May 1928): 1; "Species Improved, Sex is Determined by X-Ray on Eggs" *Washington Post* (1 May 1928): 8.

radiation on the genomes of organisms on Earth.[454] "Dr. Muller reported that the cosmic rays and the radium rays were, as far as he knew, the only things occurring in nature which might disrupt the chromosomes and thus disturb the plan fixed by nature for the individual", communicated a *New York Times* staff correspondent.[455] Popular accounts frequently contrasted the artificial mutations induced by exposure to x-ray radiation with the potent cosmic radiation credited with producing natural variation.[456] The very first newspaper feature which examined Muller's and Millikan's experiments had already emphasized the superiority of the powerful cosmic rays to the artificial, laboratory-made x-ray radiation.[457] "If man's feeble laboratory X-rays can switch evolution from one track to another, what may not be expected of the more powerful gamma rays or radium or those cosmic rays that Professor Millikan finds are able to pierce 18 feet of lead or 200 feet of water?", asked a staff writer for the *New York Times*.[458] Under Millikan's influence, the mutagenic properties of cosmic rays revealed the environment as ordered and progressive; the Creator's impeccable design. Muller's x-ray radiation, on the other hand, was depicted as enforcing disorder by "upsetting nature's plans" and producing mutations which did not fit the Creator's design and for which "nature had no use".

"Darwin rejected the two-headed calves, the malformed sheep, the monstrosities of the barn-yard as of no consequence in evolution. Today such sports are the subject of a type of experimentation in which de Vries was a pioneer", wrote a journalist in an obituary for the Dutch

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[454] By 1930, Muller and L. M. Mott-Smith proved that cosmic rays did not increase the mutation rate of *Drosophila*, see Hermann J. Muller and L. M. Mott-Smith, "Evidence that Natural Radioactivity is Inadequate to Explain the Frequency of 'Natural' Mutations" *Proceedings of the National Academy of Sciences* 16 (1930): 277-85.

[455] "Altered Heredity of Flies by X-Ray" *New York Times* (25 Apr 1928): 15. For Muller's address, see Hermann J. Muller, "The Production of Mutations by X Rays" *Proceedings of the National Academy of Sciences of the United States of America* 14.9 (Sep 1928): 714-26. For a detailed program of the scientific sessions held at the annual meeting of the National Academy of Sciences in 1928, see: National Academy of Sciences, *Report of the National Academy of Sciences. Fiscal Year: 1927-1928*, Washington: Government Printing Office, 1929: 42-3.

[456] This had been case for the British context. In his far-fetched speculative work, R. C. Macfie argued that "it has been proved that [germ-plasm] can be grossly altered by penetrating 'X' rays, and it is not impossible that more penetrating rays, like Milligan [sic] rays, may have altered the evolutionary germ-plasm at various points en route between amoeba and man" (Macfie, *Methantropos*, 11-2).

[457] "Altered Heredity of Flies by X-Ray" *New York Times* (25 Apr 1928): 15.

[458] "Cosmic Rays and Evolution" *New York Times* (26 Apr 1928): 26.

botanist in 1935.[459] By the time Muller's *Drosophila* experiments hit the newsstands, the American audiences had already been familiarized with the image of a scientist creating monsters in his laboratory, articulated on the pages of Mary Shelley's influential 1818 novel, as well as in public exposures of teratology, the science of developmental abnormalities.[460] Science journalists described Muller's mutant *Drosophila* experiments as "invading cells and effecting a profound change in living things", permanently "juggling the chromosomes", or "tampering with life forces". Applying x-ray machines to living organisms, Muller had been "[i]nterfering with the normal processes of the germ plasm", and haphazardly "shuffling the genes". Scientists who followed Muller were depicted as "snatching from nature her prerogative of devising new species of animals", "bending Nature to the scientific will", or "thwarting nature with Frankensteinian science". Genes "had been struck and twisted or sliced" by Muller, a scientist who was "willing to shake dice with nature". By 1928, the term "mutation" began to function as a synonym for deformation, sometimes called a "marked peculiarity". The expression "monstrosity" left the confines of the botanical jargon where it conveyed an abnormality of growth and entered the popular register to signify an abnormally structured organism such as a *Drosophila* mutant: Muller produced artificial "monstrosities, or what the biologist prefers to call mutations".[461] Another writer pointed out how Muller's insights were brought by the "martyrdom of fruit fly". In this example, Muller situated his accounts of mutation experiments in the language used by science journalists to

[459] "A Neo-Darwinian" *New York Times* (24 May 1935): 20.

[460] For examples of such coverage, see "The Wonderland of Biology" *Washington Post* (28 Jan 1912): 2; "How Science Creates Monsters" *Washington Post* (29 Sep 1912): 4; "Study of Life and Phenomena" *Los Angeles Times* (18 Nov 1912): 4; "Finds in Biology a Key to Monsters" *New York Times* (15 Oct 1915): 13; "Why Scientists Believe Mythical Monsters Existed" *Washington Post* (7 Nov 1915): 5; "Why Scientists Now Believe That Many Monsters Really Existed" *Richmond Times-Dispatch* 65.310 (7 Nov 1915): 7-8.

[461] Sources listed in the order of appearance: "X-Ray Held Life's Key" *Los Angeles Times* (31 Dec 1927): 1; "Cosmic Rays and Evolution" *New York Times* (26 Apr 1928): 26; "Sex-Change Achieved" *Los Angeles Times* (1 May 1928): 1; "Topics of the Times" *New York Times* (11 May 1928): 18; Floyd K. Richtmyer, "X-Rays Are Now Widely Used" *New York Times* (1 Jun 1930): 2; Miller James, "Miracles of Plant Wizardry" *Washington Post* (6 Mar 1932): 8; "Topics of the Times" *New York Times* (11 May 1928): 18; George W. Gray, "Radiation and Life" *Harper's Monthly Magazine* 169.1010 (1 Jul 1934): 210-221; Waldemar Kaempffert, "The Superman: Eugenics Sifted" *New York Times* (27 May 1928): 72; "Says X-Rayed Eggs Hatch Mostly Hens" *New York Times* (1 May 1928): 25; Waldemar Kaempffert, "The Week in Science: Measuring Genes" *New York Times* (15 May 1932): 4; R. L. Duffus, "Modern Biological Science and The Future of the Race" *New York Times* (13 Apr 1930): 66.

capture the effect of x-ray radiation on genes. In an article for the *Scientific Monthly*, he summarized previous attempts at artificial induction of mutations as based on "all sorts of maltreatment": "Animals and plants have been drugged, poisoned, intoxicated, etherized, illuminated, kept in darkness, half-smothered, painted inside and out, whirled round and round, shaken violently, vaccinated, mutilated, educated and treated with everything except affection, from generation to generation".[462]

"Nature has no use for monstrosities", remarked Waldemar Kaempffert in the *New York Times*. Dramatizing Muller's production of artificial mutations, he exclaimed at the results:

> "And what monstrosities! Flies with eyes that bulged, flies with eyes that were sunken; flies with purple, white, green brown and yellow eyes; flies with hair that was curly, ruffled, parted, fine, coarse; flies that were bald; flies with extra legs or antennae or no legs or antennae; flies with wings of every conceivable shape of wing or with virtually no wings at all; big flies and little flies; active flies and sluggish flies; sterile flies and fertile flies".[463]

Similarly to other expositions of Muller's mutations, Kaempffert's sensational catalog focused on the phenotypical consequences of genetic mutations (Figure 10). The science journalist had almost quoted verbatim the extensive description Muller had offered a few years prior in a popular magazine, *Evolution*.[464] The emphasis on the physical articulation of genetic mutations linked these representations to the problem of species which – as the previous chapters of the dissertation illustrate – had been closely related to the history of biological mutation. The understanding of mutation as a process leading to the creation of new species is evident in the coverage of Muller's experiments. Waldemar Kaempffert described "the geneticist [who] has played havoc with genes and chromosomes and produced species entirely new".[465] In a feature exploring the contemporary use of x-ray radiation, the physicist Floyd K. Richtmyer stated that with Muller's findings "the

[462] Hermann J. Muller, "The Method of Evolution" *Scientific Monthly* 29 (Dec 1929): 481-505; 489.
[463] Waldemar Kaempffert, "Darwin After 100 Years" *New York Times* (15 Sep 1935): 10.
[464] Hermann J. Muller, "How Evolution Works" *Evolution* (Feb 1931): 12-15.
[465] Waldemar Kaempffert, "Man Outdoes Nature in a Synthetic Era" *New York Times* (10 Aug 1930): 1 XX.

biologist apparently has at his disposal a laboratory method for producing new species"[466] As late as 1938, a writer for the *New York Times* described how x-ray radiation could "jolt the genes" of *Drosophila* "so that new kinds of flies are hatched which are permanent new species".[467] Even if Hermann Muller had reduced the meaning of mutation to a fundamental hereditary change at the level of the gene, the concept of genetic mutation had been shaped by an imagination of heredity which had still relied on the category of species as basic unit of biological classification.[468]

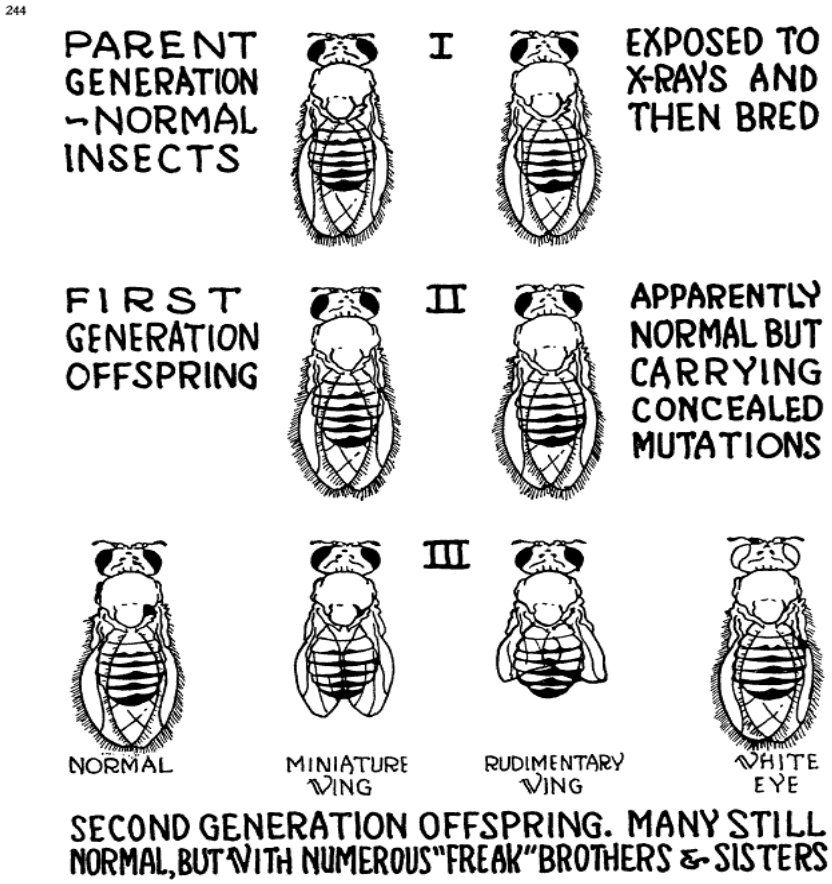


Fig 10. Visual representation of Muller's *Drosophila* mutations. Source: Frank Thone, "X-Rays Speed Up Evolution Over 1,000 per Cent" *Science News-Letter* 12.340 (1927): 243-6, doi:10.2307/3903364.

[466] Floyd K. Richtmyer, "X-Rays Are Now Widely Used" *New York Times* (1 Jun 1930): 2
[467] "Evolution 'Loafs' in Cosmic Shower" *New York Times* (23 Jan 1938): 45.
[468] Hermann J. Muller, "Variation Due to Change in the Individual Gene" *The American Naturalist* 56 (1922): 32-50. See also Campos, *Radium and the Secret of Life*, 230-2.

"The sensational character of Professor Muller's achievement may be best appreciated if we imagine him producing 100 entirely new species of human beings, some with no legs at all, some with arms of unequal length, some with other abnormalities. Biologically speaking, it makes no difference whether the subject of an experiment in controlled evolution is a fruit fly or a man", wrote a staff writer in the very first coverage of Muller's experiments in the *New York Times*.[469] The language employed by science journalists to accommodate Muller's work included a criticism of the actions executed by experimental biologists upon their natural subjects. Readers of prestigious nationwide publications were exposed to a vision of a geneticist who "disarranged nature's plans and specifications for the building of the individual", producing organisms "which had their constitutions disordered before birth by the X-rays [and] grew up with a great variety of abnormalities".[470] On the other side of the Atlantic, one would read about how "[r]ecent advances in experimental genetics [that] have conjured out of the mists of nightmarish fantasy a Frankenstein monster and dragged it into the lighted circle of ultimate probability".[471] The fantasy found its clearest articulation in a 1932 novel which offered a most compelling vision of biological control, Aldous Huxley's *Brave New World*. While some reviewers remarked that "biology is itself too surprising to be really amusing material for fiction",[472] others pointed that "what gives the biologist a sardonic smile as he reads it, is the fact that the biology is perfectly right, and Mr. Huxley has included nothing in his book but what might be regarded as legitimate extrapolations of knowledge and power that we already have".[473] Alongside ectogenesis, Huxley described the artificial production of genetic mutations through exposure to x-ray radiation, low temperature and alcohol.[474] "The present state of genetics and history both teach that man is a dangerous animal, but never more dangerous than when he undertakes to direct his own evolution", warned Kaempffert in

469 "Cosmic Rays and Evolution" *New York Times* (26 Apr 1928): 26.
470 "Altered Heredity of Flies by X-Ray" *New York Times* (25 Apr 1928): 15
471 Autosome, "The Trigger of Evolution" *New Statesman and Nation* 3.68 (11 Jun 1932): 760-2.
472 Donald Watt, *Aldous Huxley*, New York: Routledge, 2005: 207-9.
473 Joseph Needham, "Biology and Mr. Huxley" *Scrutiny* (May 1932): 76-7. (emphasis original)
474 Aldous Huxley, *Brave New World*, London: Vintage, 2004: 3-5.

1932.[475] *Brave New World* electrified the American audiences and spurred a number of science fiction stories which dramatized artificial mutagenesis.[476]

"I have always maintained that evil was not a positive force, merely negative good; a misdirection, so to speak, of the same forces that can result in good. Just so is evolution a force for good if used as the Creator intended, but woe befall humanity if its laws are tampered with", exclaimed the narrator of a 1929 science fiction story, aptly entitled "The Evolutionary Monstrosity".[477] Science editors and journalists located Muller's mutation research within the discursive environment dominated by the scientific-religious discourse which drew a vision of cosmic radiation as driving the natural process of species evolution. The argument for design had been encapsulated during this period in the popular image of "a Creator continually on the job". The press inevitably contrasted Muller's artificial mutations with natural variation resulting from exposure to the powerful cosmic radiation. Responding to the strong scientific-religious current, science journalists accommodated Muller's production of mutations in the public sphere by developing a particular discourse of genetic manipulation which positioned mutant *Drosophila* as organisms that diverted from "nature's plan" and interfered with the natural order.

## 4.5 *Conclusion*

"The evidence is strong that the vast majority of artificial variations, many of them monstrosities, are unfit for this world. Natural selection kills them off. And so it will probably prove to be if ever we attempt to 'improve' the human species by thwarting nature with the aid of Frankensteinian science".[478] The above passage which appeared in the popular "Topics of the Times" section of the *New York Times* offers a glimpse into the type of discourse advanced by the

[475] Waldemar Kaempffert, "Genetic Principles" *New York Times* (25 Sep 1932): 17.
[476] For examples of such stories, see Edmund Hamilton, "Master of the Genes" *Wonder Stories* 6.8 (1935): 958-69; Clare Winger Harris, "The Evolutionary Monstrosity" *Amazing Stories Quarterly* 2.1 (1929): 70-7.
[477] Harris, "The Evolutionary Monstrosity", 73.
[478] "Topics of the Times" *New York Times* (11 May 1928): 18.

contemporary science editors and journalists to describe the activities of geneticists. As the chapter illustrates, the press representations of Muller's experiments were located at an intersection of different threads. The newly-emergent profession of science journalism determined the course of these representations within its own attempt at constructing the national ideology of science, guided by its particular motivations for popularizing science among the American audiences, and the belief in a deficiency characterizing humankind facing the modern world. Hence the profusion of expositions which did not foreground Muller's experiments in relation to the discipline of genetics, or to the practical agricultural or industrial interests, instead focusing on their significance for the widespread fantasy of improving the human species.

Even if Muller's *Drosophila* experiments rendered the geneticist famous among the American audiences as the scientist responsible for discovering the mutagenic properties of x-ray radiation, and the geneticist's interpretations of his research reverberated across these press expositions, his problematic public status and lack of experience in popularization prevented him from controlling the accuracy of these representations.[479] Consequently, Muller's suggestions about the risks involved in the use of x-ray machines in medical contexts passed almost entirely ignored during these decades, and resurfaced only during the 1940s and 1950s in the public reactions the threat of fallout from nuclear tests conducted on the territory of the United States. Muller's mutation experiments became entangled with the scientific-religious discourse through their frequent association with cosmic rays, influentially interpreted by a recognized figure in the American science, Robert A. Millikan, who controlled the public expositions of his research. Muller's x-ray mutations entered into a dialog with Millikan's cosmic rays which had prompted the widespread interpretation of evolution as a theistic process, and natural variation as revealing nature's design.

[479] A contributing factor might have been Muller's mental health. The news about his suicide attempt in 1932, at the time interpreted as a mental breakdown, had appeared across the local and national press, see "Guardsmen Find University Professor" *Big Spring Daily Herald* 4.193 (12 Jan 1932): 1; "Altenburg Back From Austin as Muller Found" *Rice Thresher* 17.16 (15 Jan 1932): 2; "Lost Scientist Found Wandering in Hills" *Washington Post* (13 Jan 1932): 10.

Cosmic rays were interpreted as potent radiations that could impact the genotypes of organisms living on Earth: "Cosmic rays, by bombarding thousands of your ancestors and changing your heredity, have done much to make you what you are", wrote William S. Barton for the *Los Angeles Times*.[480] They served as proof of the continuity of God's creation and a potential explanation for biological variation within the order of nature. "Chromosomes and genes–who knows but they are the playthings of the terrific forces that tear down and build up atoms in stars millions of light-years distant and in the process create Millikan's rays?", asked a *New York Times* writer.[481]

The public fascination and revulsion with fruit fly mutations intermingled as they promised the control of the evolutionary process, frequently extrapolated to humans. Science journalists represented x-ray mutagenesis as an interference in the natural order since geneticists who exposed fruit fly genomes to these penetrating rays distorted "nature's plan": "Most of these mutations […] die because they depart too radically from the norm. Nature does not want them. But the nearest to the norm survive", wrote Waldemar Kaempffert for the *New York Times*.[482] Muller's experimental use of x-ray radiation not only interfered in the natural order but also revealed the intrinsic structural disorder of living organisms. In a review of Lancelot Hogben's study of the genetic principles in medicine and social sciences, Waldemar Kaempffert narrated the consequences of the discovery of genes as carriers of hereditary traits in the following manner: "It turned out that every one of us is the carrier of bad genes, that insanity is concealed in every family, that monstrosities may break out anywhere at any time".[483] By accelerating the rate of mutation, Muller's experiments exposed the potential for "monstrosity" inherent to every genotype. The press representations of Muller's *Drosophila* experiments frequently emphasized the quality of "monstrosity" apparent in organisms created in the laboratories of geneticists. Science journalists accommodated the concept

[480] William S. Barton, "Cosmic Ray Effect on Heredity Told" *Los Angeles Times* (30 Dec 1951): 1 (Part 2).
[481] "Cosmic Rays and Evolution" *New York Times* (26 Apr 1928): 26.
[482] Waldemar Kaempffert, "Science: The Aims of the New Cosmic-Ray Survey" *New York Times* (2 Feb 1936): 4.
[483] Waldemar Kaempffert, "Genetic Principles" *New York Times* (25 Sep 1932): 17.

of biological mutation in relation of the often overlapping categories of “new species” and “monstrosities”, continuing the line of association which linked the problem of mutation with the prevailing debate between the proponents of gradualism and saltationism in evolution, explicitly evident in the case of Hugo de Vries's mutation theory described in the previous chapter. Interpreting Muller's induced genetic mutations within the authoritative narrative of nature captured in the scientific-religious discourse, science journalists formulated a cultural definition of genetic mutation which encapsulated the promise and peril of genetic engineering that would extend throughout what Evelyn Fox Keller famously named “the century of the gene”.[484]

[484] Evelyn Fox Keller, *The Century of the Gene*, Cambridge, MA: Harvard University Press, 2000.

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## Conclusion

Initiating this project, I intended to examine the history of public engagement with the idea of modifying the inherited traits of living organisms by tracing the circulation of scientific knowledge about biological mutation among different segments of the American society. The analysis of the public discourses which originated around the concept of biological mutation – assuming the form of species transmutation, the mutation theory, or genetic mutation – has enabled me access the discursive space where these early interactions took place. By investigating the press representations of biological mutation produced during the nineteenth and early twentieth century in the United States, I have also addressed a significant chronological and geographical gap in the history of science popularization which is dominated by accounts exploring popular renditions of science in Victorian Britain. As I have come to understand, the accommodation of scientific knowledge in the press can be examined productively when such representations are located in a space occupied by different variants of knowledge which collide and compete, for instance, interpretations communicated between the members of expert communities, or widespread religious beliefs about the natural environment. Focusing on the different modes of accommodating science in the public sphere by media professionals in such a broad discursive context allowed me to compare and analyze the expositions of biological mutation articulated by different social groups involved in presenting scientific knowledge to the public.

Exploring the strategies employed in constructing the meanings of biological mutation, I have demonstrated that the knowledge about the possibility of altering the hereditary traits of living organisms had been shaped by the particular objectives, expectations, and requirements expressed by these social groups. And thus, the nineteenth-century intellectual reformers who coordinated the activities of the agricultural press used the medium to promote the authority of science in the study

of nature with the goal of installing the improvement ideology among the antebellum agrarian community, relying on the interpretations of nature offered by the most prominent American natural historians. During the Progressive Era, the American – and especially Californian – newspapers offered representations of scientific plant breeding which resonated with the arguments promoted by the American followers of Hugo de Vries who advocated the practical implications of the botanist's theory of mutation as a means of establishing their disciplinary authority. The 1920s witnessed the rise of the profession of science journalism, supported by institutions which aimed at democratizing scientific knowledge by offering quality reporting on science and technology topics. As the dissertation shows, it was the constellations of these individuals and groups who negotiated the legitimacy of new knowledge that had shaped the image of biological mutation in the American public sphere. The dissertation also indicates that dividing the narratives produced in media formats intended for different audiences is problematized by the frequency with which expert and lay interpretations of scientific knowledge traveled back and forth in a single discursive space.

Locating these different clusters of press representations in such a rich context allowed me to trace the transformation of the public language of science under the pressure of authoritative narratives of nature which dominated the discursive landscape when the public expositions of biological mutation intensified on the pages of the American press. Each chapter of the dissertation thus describes the circumstances which lead the American editors and journalists to articulating the "unnaturalness" problem in relation to the manipulation of plant and animal organisms, indicating the historical dimension of the discourses of nature mobilized by the social movements campaigning against genetic engineering in the 1990s that are still reverberating among the American public.

I. *Facets of Public Engagement with Biological Mutation*

The three historical episodes examined in the dissertation illustrate the existence of a discursive space in the American public sphere that allowed for the exposition of the concept of biological mutation since the second quarter of the nineteenth century. The episodes thus supplement the existing scholarship on the history of the scientific manipulation of genomes and chromosomes in agricultural and industrial contexts by demonstrating the presence of public engagement with the topic among the American audiences before the development of rDNA technologies in the 1970s. The dissertation shows that the American society confronted the possibility of such interventions during the antebellum period, and interacted with organisms that had been modified by botanists or geneticists prior to the emergence of laboratory methods for genetic recombination. Enveloped in the rhetoric of progress and improvement, the Northeastern agrarian community participated in a lively debate about species transmutation which had at the time been silenced in the exchanges between the members of the American scientific community. The editors of the agricultural press urged their readership to conduct experiments, offering instructions for inducing species transmutation by exposing wheat seeds to frost or humidity. At the dawn of the twentieth century, the American audiences were exposed to the research agenda of Hugo de Vries's followers, most notably Daniel T. MacDougal whose experiments with mutagenic agents such as radium or mineral solutions appeared in the extensive press coverage of scientific plant breeding. The late 1920s presented yet another occasion for the American audiences to interact with the concept of induced biological mutation in the widespread coverage of Hermann J. Muller's experiments with *Drosophila*. Foregrounding the mutagenic properties of x-ray radiation, science writers combined their reports with coverage of "cosmic rays" that were supposedly responsible for spontaneous variation occurring in the natural environment, bringing the problem of manipulating genomes to the forefront of the public imagination of the burgeoning science of genetics.

Each of these episodes also indicates the presence of the public perception of "unnaturalness" associated with the modification of the hereditary traits of living organisms. The American press represented the concept of biological mutation in various forms over the one hundred twenty-five years covered in the present dissertation. Whether conceptualized as species transmutation, the theory of mutation or genetic mutation, the concept of biological mutation emerged in the public sphere accompanied by reports of tools and techniques that would harness the capacity of living organisms to undergo hereditary modification. The problem of controlling the heredity of plants, animals, and – inevitably – human beings, arose under these circumstances together with the problematic of unnaturalness. The idea of species transmutation was deemed by the community of educated reformers a mere superstition that inhibited the American Northeast from joining the momentum of agricultural progress. However, numerous contributors to the agricultural press situated species transmutation in opposition to the known botanical laws governing nature, but also to the image of nature as an order. Editors and journalists who provided coverage of Hugo de Vries's mutation theory emphasized the growing entanglement of science and farming, foregrounding the artificiality of scientific breeding products created in laboratories. The problematic of unnaturalness emerged in full force in the coverage of Hermann J. Muller's fruit fly mutations as science writers aligned the concept of genetic mutation with the exemplary phenotypical deformations, emphasizing the impossibility that such mutations or "monstrosities" could ever occur spontaneously.

Each chapter of the dissertation offers reasons accounting for the articulation of the "unnaturalness" problem by the American press. Examining the processes of adapting scientific knowledge by the American editors and journalists to the requirements and expectations of their audiences, each chapter illustrates how the representations of biological mutation transformed under the pressure of authoritative narratives of nature which occupied the same discursive space. The

public reactions to the proposition of species transmutation published on the pages of nineteenth-century agricultural periodicals framed the problem within the tenets of the American natural theology which presented the nature as a sacred order. The popularity of Hugo de Vries's mutation theory among the Californian audiences involved the intensification of expositions about scientific breeding practices which implied an interpretation of nature that stood in stark contrast to the early American environmentalism captured in John Muir's influential writings. Hermann J. Muller's mutation research clashed with Robert Millikan's cosmic rays, a topic enveloped in the scientific-religious discourse of nature which postulated the existence of a natural order. In all three cases, the representations of biological mutation implied that the hereditary characteristics of living organisms are mutable and liable to modification. As the dissertation indicates, such an implication encountered more or less explicitly articulated objection from individuals holding a range of essentialist assumptions which appeared in the contemporary narratives of nature circulating in the discursive context. These narratives shaped – and in many cases still continue to shape – the public engagement with products and processes of hereditary modification.

The juxtaposition of the natural and artificial variation linked the problematic of "unnaturalness" to the tradition of biological classification, a connection which had already appeared among the American agrarian communities during the first half of the nineteenth century. As each chapter of the dissertation illustrates, in the American public sphere the notion of biological mutation was inexorably tied to the problem of species variation and evolutionary history. The nineteenth-century debate about the origin of chess explicitly aligned the process of transmutation with the emergence of new species. Press representations of the mutation theory referred to the problem of species generation equally explicitly, depicting Hugo de Vries as "the first investigator to watch the formation and development of new species", who allowed breeders to improve their understanding of the conditions leading to species generation.[485] Muller restricted the meaning of

[485]"A Sudden Development of Species" *Popular Science News* 35.3 (Mar 1901): 65.

biological mutation to a fundamental hereditary change at the level of the gene. However, the interwar science journalism continued to represent the concept of mutation in terms of its manifestation in an organism's observable characteristics, thus retaining its connotation with the species problematic. In the language of science writers, the expression "mutation" began to serve as a substitute for notions such as deformity or monstrosity as they commonly depicted fruit fly mutations as unfit for surviving in the natural environment. During each of the examined historical episodes, editors and journalists emphasized the artificiality and unnaturalness of organisms undergoing a type of mutation, shaping their representations under the influence of authoritative narratives of nature where species fixity served as the foundation for conceptualizing nature as an order.

As I have delineated in the introductory section of the present dissertation, the problem of species was also present in the rhetoric employed by the opponents of genetic modification and has been circulating among the American and European audiences since the late 1990s. The influential GMO opponent Jeremy Rifkin frequently referred to the problem of species when discussing the differences between traditional breeding techniques and genetic engineering. In an interview from 2001, he stated:

> "But you can't cross a donkey and an apple tree in classical breeding. What the public needs to understand is that these new technologies, especially in recombinant DNA technology, allow scientists to bypass biological boundaries altogether. You can take a gene from any species – plant, animal, or human – and place it into the genetic code of your food crop or other genetically modified organism. Crossing genetic information from one species to another is something we've never seen in 10,000 years of classical breeding...."[486]

The emphasis on the problem of species appears in contemporary assessments of the early

[486] John Palfreman, "Interviews. Jeremy Rifkin" *Harvest of Fear*, PBS, 2001, http://www.pbs.org/wgbh/harvest/interviews/. Accessed: August 2016.

GMO debate as well, for instance, in the informational materials produced by the World Health Organization regarding food technologies. As an answer to the question about the widespread social concern relating to the introduction of GMOs into markets and ecosystems, present among the politicians, consumers, as well as public interest groups, the WHO listed a number of reasons to account for these public perceptions. One of such fundamental factors related genetic modification to species generation: "In the case of food, consumers started to wonder about safety because they perceive that modern biotechnology is leading to the creation of new species".[487] The three historical episodes thus examine previous instances of such perceptions connected to the problematic of species which – as I have indicated in the introduction of the present dissertation – represent a significant theme in the scholarship which examines the social responses toward agricultural biotechnologies. The dissertation thus hopes to expose the continuing appearance of the species problematic in the history of public reactions to modifying hereditary traits of living organisms and indicate the historical dimension of a similar tendency present in the contemporary public perceptions of genetic modification. Recent developments in the field of biotechnology, in particular the introduction of the genome editing tool, CRISPR-Cas9, may be expected to impact the tone of the public debate about genetic modification of living organisms, perhaps in time removing the issue of species or the concern about the unnaturalness of transgenic organisms from the foreground of the public imagination of genetic engineering.

## II. *Further Directions for Research*

Focusing on the process of the adaptation of scientific knowledge by editors and journalists,

[487] WHO, "Frequently Asked Questions on Genetically Modified Foods", http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/. Accessed August 2016.

the present dissertation concentrates on the representations of scientific knowledge offered in the American press, thereby reducing the presence of other media formats, for instance, the print media such as books, or broadcast media such as the radio. The history of science coverage in the American media remains underresearched when compared to the range and scale of investigations regarding the presence of science and technology, in particular life sciences, in the British media during the nineteenth and twentieth century.

The dissertation is also marked by a number of chronological constraints. The present study does not discuss the representation of biological mutation during the second half of the nineteenth century, occurring in the context of the American reception of Charles Darwin's theory of evolution by natural selection, popularized by figures such as John Fiske or Henry Drummond.[488] The period in question did not offer significant public coverage of the concept, as the American press tended to foreground the sensational implications of Darwinian evolution such as common descent, or its implications on the development of societies, in particular, Herbert Spencer's notion of the survival of the fittest. The widespread representations of the evolutionary process during that period accentuated its gradualism, offering relatively few opportunities for discussing topics such as variation or species generation.

Since the present dissertation traces the public history of biological mutation from 1820 until 1945, it fails to address the shaping of public discourses about biological mutation following the Second World War. The 1950s and 1960s witnessed the renewed interest in the concept among the American society due to a variety of reasons ranging from the discovery of

[488] See Kimberly A. Hamlin, *From Eve to Evolution: Darwin, Science, and Women's Rights in Gilded Age America*, Chicago: University of Chicago Press, 2014; Bernard Lightman, "Darwin and the Popularization of Evolution" *Notes and Records of the Royal Society of the History of Science* 64.1 (2010): 5-24; Ronald L. Numbers and John Stenhouse (eds.), *Disseminating Darwinism: The Role of Place, Race, Religion, and Gender*, New York: Cambridge University Press, 1999; Ronald L. Numbers, *Darwinism Comes to America*, Cambridge, MA: Harvard University Press, 1998; Carl N. Degler, *In Search of Human Nature: The Decline and Revival of Darwinism in American Social Thought*, New York: Oxford University Press, 1991; Jon H. Roberts, *Darwinism and the Divine: Protestant Intellectuals and Organic Evolution, 1850-1900*, Madison: University of Wisconsin Press, 1988.

the structure of DNA and advances in the field of radiation genetics to the flurry of public debates about the pathogenic effects of radiation on living organisms following the American nuclear testing programs. The concept of biological mutation which had previously stood for the capacity for plasticity of living organisms began to be openly associated with risk. In his survey of the engagement with de Vriesian variant of mutation in the period, Jörg T. Richter argued that the concept of mutation "seemed to have lost its earlier undertone of evolutionary innovation and turned into a metaphor for risk instead".[489] Geneticists such as Francis Crick, Linus Pauling, Joshua Lederberg, or Hermann J. Muller emphasized that the presence of risk factors such as radiation emitted from nuclear testing could render the American population susceptible to an accumulation of deleterious mutations, designated by Muller as the "mutation load". Muller became the center of the public controversy about the biological hazards of radiation in 1955 when his paper was rejected from the Geneva Conference on Peaceful Uses of Atomic Energy.[490] The idea of "monster mutations" circulated in popular culture during the 1950s, spawning a proliferation of films and comic books on the topic.

The public history of biological mutation in the United States extends beyond the 1950s. In 1962, Rachel Carson published *Silent Spring*, provoking a public outcry against DDT and other toxic elements. The American press offered extensive coverage of various such substances ranging from chemical and air pollutants to flame retardants, dioxins such as the infamous Agent Orange, or Diethylstilbestrol (DES). The presence of such substances in the public sphere provoked frequent press expositions of their associated risks, among others

[489] Jörg T. Richter, "The Fate of Mutation: Shift, Spread, and Disjunction in a Conceptual Trajectory" *Contributions to the History of Concepts* 6.2 (2011): 85-104; 100.

[490] For reactions of the American community of geneticists, see "Radiation and Human Heredity: Comment from Geneticists" *Bulletin of the Atomic Scientists* 10.10 (1955): 364-6. For a selection of press coverage, see Warren Unna, "AEC Accused of Blocking A-Report" *The Washington Post and Times Herald* (17 Sep 1955): 1; "A. E. C. Bares Curb on Nobel Winner: Banned Thesis on Hiroshima at the Geneva Meeting on Peaceful Uses of Energy" *The New York Times* (18 Sep 1955): 54; Warren Unna, "The Muller Case. AEC Explanations Vary" *The Washington Post and Times Herald* (19 Sep 1955): 21; Eugene Rabinowitch, "Banned Atomic Paper is Opposite of 'Alarmist'" *The Washington Post and Times Herald* (6 Nov 1955): 3.

their impact on the genomes of populations that were exposed to them. Tracing these public engagements with biological mutation should, therefore, provide an opportunity to explore the more recent history of the lay perceptions regarding the manipulation of genomes which had contributed to building the foundation for the public perceptions of genetic engineering following the commercialization of the first genetically modified products in the United States.

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