ANTICIPATING THE STORM: Predicting and Preventing Global Technology Conflicts

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This article helps lay the foundation for a new field of international law—International Law and Technology—and opens novel avenues of inquiry in law and technology and intellectual property more broadly. It analyzes as a starting point why some technologies generate global conflicts while others do not. Technologies that face international resistance can trigger a barrage of international legal responses, ranging from trade bans and WTO disputes to international regulatory regimes and barriers to patenting. Agricultural biotechnology triggered all of these legal flashpoints, while the cellphone, a technology that grew up alongside it, triggered none. Why?

Understanding when a new technology will provoke an international legal firestorm is important to policymakers, business leaders, and lawyers. International controls on a new technology constrain state sovereignty and may impede or catalyze the development of an emerging technology. Technologies likely to generate international controversy bode poorly for regulatory harmonization regimes as contemplated by the new transatlantic trade talks. At a minimum, they require sensitive handling.

This article offers a framework of core geopolitical factors that can help predict the international acceptability of an emerging technology and its likelihood of triggering a plethora of international legal issues. The framework can help decision-makers avoid global technology conflicts and better manage these conflicts once they arise. The first factor is whether the technology is "a big- or a small-tent technology" from a global perspective, as reflected (1) in the innovative space, (2) in the marketplace, and (3) in the sphere of benefit sharing. To illustrate the analysis, the article presents original empirical patent data for the cellphone and agricultural biotechnology over three decades. This comparison highlights the importance of global innovative activity to international technology comity.

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The second core predictive factor is whether a new technology embodies nations' fears of the future, as did agricultural biotechnology, or reflects their dreams, as did the cellphone. The first factor is utilitarian; the second is emotional.

INTRODUCTION

Calgene developed the first genetically-modified whole food, a tomato genetically-engineered to delay rotting, in 1990. By 1999, the majority of U.S. bulk shipments of staple commodities of corn and soybean were genetically-modified. These grains generated an international firestorm. European nations closed their doors to these shipments, causing U.S., Canadian and Argentinean farmers to lose hundreds of millions of dollars in exports per year. In response, the United States, Canada and Argentina initiated a major trade dispute against the European Union before the World Trade Organization.[1] Meanwhile, famine-faced Zambia, Zimbabwe, Lesotho, Malawi, and Mozambique turned away donations of tons of bioengineered grain, leaving 2.9 million people at risk of starvation in Zambia alone.[2] Over 150 nations demanded the negotiation of an unprecedented treaty to govern the trade in these grains.[3]

While negotiating this treaty in the late 1990s, delegates held cellphones to their ears. They transmitted their fears of bioengineered grains over these hand-held devices, unconcerned about any cancer risks and other health threats that these radiation-emitting devices potentially posed.

Today goods travel the globe at an unprecedented rate and speed. They pierce borders and societies that may not be ready for them. They can engender massive international tension and challenge international organizations, international businesses, and domestic and international legal systems as they attempt to manage and diffuse these tensions. Emerging technologies can give rise to a host of international legal issues. These include international intellectual property issues, international trade issues, and international regulatory issues. Bioengineered food triggered all of these legal flashpoints, while the cellphone, a technology that grew up alongside it, triggered virtually none. Why?

Understanding when a new technology will provoke a strong international legal response is important to policymakers, businessmen, and lawyers. All else being equal, international controls on a new technology constrain state sovereignty. Such controls may impede or catalyze the development of a new technology, depending on the extent of the coordination problem the technology presents. Technologies likely to generate international controversy bode poorly for regulatory harmonization regimes as contemplated by the new transatlantic trade talks. At a minimum, they require sensitive handling.

Is there a way to anticipate which technologies will likely engender controversy so as to avoid global technology conflicts and better manage these conflicts once they arise? This article tackles this question and helps lay

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1. Panel Report, *European Communities—Measures Affecting the Approval and Marketing of Biotech Products*, WT/DS291/R (Sept. 29, 2006).

2. John Bohannon, *Zambia Rejects GM Corn on Scientists' Advice*, 298 SCI. 1153, 1153–54 (2002) (Zimbabwe, Lesotho, Mozambique and Malawi eventually accepted genetically-modified grain, but only after it had been milled into flour); *see also* CASS SUNSTEIN, LAWS OF FEAR 31–32 (2005).

3. FIONA MCCONNELL, THE BIODIVERSITY CONVENTION A NEGOTIATING HISTORY ix (1996).

the foundation for a new field of international law: International Law and Technology.

While there has been excellent work on the agricultural biotechnology controversy and theories for its occurrence, scholars have not compared the agricultural biotechnology experience to the international experience of any other contemporaneous watershed technology. Taking a broader perspective enables greater understanding of determining factors. The cellphone experience, for example, adds to skepticism that the European Union has a more precautionary regulatory approach to new technologies than does the United States. It also limits the public scares, culture, and institutional factors explanations for the extensive regulation of a technology.[4]

More importantly, this article offers a more universal message. It argues that some technologies and the way they make their appearance on the world stage are more likely to create global technology conflicts than others. Admittedly, no single touchstone exists to predict whether an emerging technology will enjoy international acceptance. However, a close analysis of the international experience of two contemporaneous path-breaking technologies reveals attributes that make international acceptance or rejection more or less likely.[5] Based on this analysis, this article develops a novel framework of core geopolitical factors that can help predict whether an emerging technology will provoke a strong international response.

The first factor is whether the technology is "a big- or a small-tent technology" from a global perspective as reflected (1) in the innovative space, (2) in the marketplace, and (3) in the sphere of benefit sharing. To illustrate the analysis, the article presents original empirical data on patent applications for agricultural biotechnology and cellular telephone technology over three decades. This data shows that from the earliest stages of the technologies, the cellphone exhibited global diversity in inventive activity, while agricultural biotechnology did not. Building upon the work of Graff and Zilberman, this article emphasizes global innovative activity as being key to international technology comity. The emergence of India and China as innovative powerhouses portends, under this criterion, fewer technology conflicts, at least in their areas of innovation.

The article then demonstrates how cellphone technology, in contrast to agricultural biotechnology, was characterized by global diversity at the production level and also by significant international joint ventures. Finally, while nations had traditionally considered genetic resources to form part of the common heritage of mankind, radio spectrum had long been recognized

4. *See* discussion *infra* Part II.E.
5. *See infra* Part III.

as a resource subject to government access regulation. This enabled governments and the nations they represent to make money from cellular communications by auctioning radio spectrum in a way that has eluded them in the case of genetic material.

The second core predictive geopolitical factor is whether a technology embodies nations' fears of the future or their dreams. The first factor is utilitarian; the second is more emotional.

Some technologies by their very nature are more likely to raise consumer concern than others, which will or may shape the legal response to the technologies. For example, technologies that pierce the boundaries of bodily integrity, such as food or eventually computer implants, are more likely to generate consumer opposition than those that do not visibly intrude on bodily integrity. A detailed exploration of these important consumer-based factors is the subject of a subsequent article.

This article begins by first exploring, in Part I, the legal response to agricultural biotechnology and to cellular telephone technology both internationally and under domestic laws. It reveals dramatically different legal reactions. Part II embarks upon the analysis of the international acceptability of a new technology by considering whether the disparate legal approaches to the two technologies exposed in Part I find explanation on the basis of their disparate benefits to consumers and different risks posed. The risks presented by the cellphone and the global legal response to those risks have received surprisingly little attention in the legal literature. Part II then probes current explanations for the agricultural biotechnology controversy in light of the cellphone experience. It shows that these explanations do not satisfactorily explain the diametrically different legal approaches to the two technologies.

Part III develops the analytical framework of key geopolitical factors that can help predict the global acceptability of an emerging technology and its likelihood of triggering a robust international legal response. This framework opens up a new field of inquiry in international law as well as in law and technology and intellectual property more broadly. It helps actors predict how a technology will be received from a global legal perspective. Applying it, policymakers will be able to understand, *ex ante*, how international law will respond to emerging technologies like nanotechnology, 3D printing and synthetic biology.

I. THE INTERNATIONAL AND DOMESTIC LEGAL RESPONSE TO AGRICULTURAL BIOTECHNOLOGY AND TO THE CELLPHONE

A. Background

In the early 1970s, Stanley Cohen of Stanford University and Herbert Boyer of the University of California developed a technique for isolating DNA and moving it from one organism and combining it with genetic material from another.[6] This revolutionary technology enabled humans to manipulate genes within a species as well as to pierce the natural barriers of biological incompatibility.[7] That which hitherto could not be combined could now fuse. Modern biotechnology was born.

"What the world really needs," wrote Dr. Martin Cooper to his superiors at Motorola in October of 1972, "is a handheld portable phone."[8] At that time, the only portable phones were in cars.[9] They weighed thirty pounds, had a transceiver that took up half of the car's trunk and, at four thousand dollars in the United States and almost three thousand dollars in Europe, cost more than most cars at the time.[10] Two months later, Motorola developed a prototype—a two and a half pound plastic brick affectionately called the "shoe phone" after the television comedy *Get Smart's* gag of its inspector making phone calls from his shoe.[11] On April 3, 1973, Cooper placed the world's first cellular phone call from a Manhattan street corner. Pedestrians gaped in amazement as Cooper chatted while he strolled down the street.[12]

A cellphone is actually a two-way radio that mimics a traditional phone. Cellphones operate by sending radio signals to a central tower. In the decade between Cooper's phone call and the first public sale of the shoe phone, countries began to create cellphone systems, beginning with Japan in 1979, Finland in 1982 and the United States in 1983.[13]

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6. DANIEL LEE KLEINMAN, SCIENCE AND TECHNOLOGY IN SOCIETY 16 (2005).
7. *Id.*
8. DEVRA DAVIS, DISCONNECT 13 (2010).
9. *Id.* at 24.
10. *Id.*
11. *Id.* at 23–24, 26.
12. Tas Anjarwalla, *Inventor of Cell Phone: We Knew Someday Everybody Would Have One*, CNN.COM (July 9, 2010), http://www.cnn.com/2010/TECH/mobile/07/09/cooper.cell.phone.inventor/.
13. GUY KLEMENS, THE CELLPHONE: THE HISTORY AND TECHNOLOGY OF THE GADGET THAT CHANGED THE WORLD 65–67 (2010).

The shoe phone, renamed the DynaTAC, finally became publically available in March of 1984.[14] The DynaTAC was not the only remarkable technological introduction of that time. Only a few months earlier, the world witnessed the first expression of a plant gene in a different species of plant.[15]

The tomato is the second most internationally traded fresh fruit or vegetable by volume, surpassed only by the banana.[16] It is the world's second most valuable fresh fruit or vegetable in terms of total global trade value, surpassed only by the orange.[17] In order to ship tomatoes, growers pick them when they are green and hard. So green that when the chairman of the agricultural biotech company Calgene first viewed a videotape of the harvesting process he exclaimed: "It's the wrong god-damned tape . . . those are apples!"[18] Upon reaching distributors and grocery stores, the green tomatoes are gassed with ethylene to turn them pink.[19] Not surprisingly, green gassed tomatoes do not taste good.

Calgene set out to develop a better tomato. In 1990, it flipped the genes within the tomato that cause tomatoes and other plants to rot.[20] By delaying the rotting process, Calgene had extended the shelf life of vine-ripened tomatoes from three to four days to seven to ten days.[21] The company named this miracle fruit the Flavr Savr Tomato.

B. Legal Response to Biotechnology

From the outset, the prospect of bioengineered food raised international concern. By the mid-1980s, the United Nations Environmental Program (UNEP), the World Health Organization (WHO), and United Nations Industrial Development Organization (UNIDO) had assembled expert groups to consider the safe handling of biotechnology.[22] The primary, albeit unlikely, international forum for the vetting of this concern was and remains the Convention on Biological Diversity (CBD). The CBD emerged from the

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14. Associated Press, *Motorola Phones*, N.Y. TIMES, Mar. 14, 1984, at D4.

15. KLEINMAN, *supra* note 6, at 16.

16. European Comm'n Directorate-Gen. for Agric. and Rural Dev., *Agricultural Commodity Markets Past Developments Fruits and Vegetables: An Analysis of Consumption, Production and Trade Based on Statistics from the Food and Agriculture Organisation (FAO)*, at 5 (July 17, 2007) [hereinafter EC Commodity Markets].

17. *Id.* at 6.

18. BELINDA MARTINEAU, FIRST FRUIT: THE CREATION OF THE FLAVR SAVR TOMATO AND THE BIRTH OF GENETICALLY ENGINEERED FOOD 8 (2001).

19. *Id.*

20. *Id.* at 5.

21. *Id.* at 207.

22. MCCONNELL, *supra* note 3, at 5–6.

1992 Rio Earth Summit and constitutes one of the most widely joined treaties ever. Only the United States, Andorra and the Vatican are not a party.[23]

The UNEP Governing Council authorized the preparation of the CBD in May of 1989.[24] Almost immediately, demand arose for the agreement to regulate biotechnology. As early as the summer of 1990, UNEP established a special sub-working group on biotechnology.[25] The regulation of biotechnology appeared on the list of items for inclusion in the CBD at the very first negotiating session for the treaty in November of 1990.[26] While scholarly attention has focused on the tension between the United States and the European Union vis-à-vis biotechnology, the initial demand for and insistence upon an international prior informed consent procedure for biotechnology came from developing countries and was authored by Malaysia.[27] Sweden was the first developed country to support the idea, followed by the other Scandinavian countries.[28]

The CBD essentially requires nations to domestically regulate biotechnology[29] and to share information internationally on their potential adverse affects.[30] It further stipulates that the Parties to the CBD will consider whether to develop a protocol to regulate biotechnology.[31]

In sum, while, as we shall see below, there existed no international requirement that countries regulate the health and environmental effects of cellphones and while genetically-modified (GM) foods had yet to be commercialized, by the 1992 Earth Summit, the international community had agreed that nations should regulate biotechnology domestically and had laid the groundwork for regulating it internationally. As soon as the Convention entered into force in 1993, its Parties began work[32] on a protocol to regulate

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23. *List of Parties*, CONVENTION ON BIOLOGICAL DIVERSITY, http://www.cbd.int/convention/parties/list/ (last visited Sept. 25, 2014).

24. U.N. Env't Programme Rep. of the Governing Council, May 15–26, 1989, U.N. Doc. A/44/25; GAOR, 44th Sess., Supp. No. 25 (1989).

25. *See* U.N. Env't Programme Rep. of the Ad Hoc Working Group of Experts on Biological Diversity, Biotechnology: Concepts and Issues for Consideration in Preparation of a Framework Legal Instrument for the Conservation of Biological Diversity, July 9–13, 1990, UNEP/Bio.Div.3/7 (1990).

26. MCCONNELL, *supra* note 3, at 26.

27. Veit Koester, *The Biodiversity Convention Negotiation Process and Some Comments on the Outcome*, 27 ENVTL. POL'Y & L. 175, 181 (1997).

28. MCCONNELL, *supra* note 3, at 87.

29. Convention on Biological Diversity, art. 8(g), June 5, 1992, 31 I.L.M. 818, 823.

30. *Id.* at art. 19(4).

31. *Id.* at art. 19(3).

32. First Ordinary Meeting of the Conference of the Parties to the Convention on Biological Diversity, Nassau, Bah., Nov. 28–Dec. 9, 1994, dec. I/9, UNEP/CBD/COP/1/17 (establishing a biosafety experts group).

biotechnology as a matter of international law.[33] Approximately 130 nations participated in the negotiation of the Biosafety Protocol. The Protocol was adopted in 2000 and entered into force in 2003.[34] Today, it has an impressive 167 parties.[35]

The Biosafety Protocol represents a milestone in international law. Never before had nations adopted a treaty to regulate the peaceful use of an emerging technology. The Protocol will serve as the blueprint for any future treaty to regulate a nascent technology. The Protocol spans forty articles and has three annexes. It establishes an advanced informed agreement system for genetically modified organisms intended for release into the environment, such as seeds for planting.[36] It also provides for risk assessments on bulk commodities that are not intended for release into the environment, such as corn for processing into corn oil.[37] While nations had promulgated advance informed consent systems as a matter of domestic law, internationally mandated ones had previously been reserved for dangerous substances like hazardous wastes and hazardous chemicals and pesticides.[38]

The Protocol also requires nations to share regulatory decisions and information about genetically modified organisms through an impressive biosafety clearinghouse.[39] The Parties to the Protocol have held numerous meetings, where they have sought, *inter alia*, to establish detailed requirements for the labeling of genetically modified foods. They have even adopted a Supplementary Protocol to the Biosafety Protocol to provide for liability and redress for any damage to biodiversity from genetically modified organisms.[40]

Prior to and apart from the Protocol, many nations had regulated bioengineered food, including, among others, the United States, the European

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33. Second Ordinary Meeting of the Conference of the Parties to the Convention on Biological Diversity, Jakarta, Indon., Nov. 6–17, 1995, dec. II/5, UNEP/CBD/COP/2/19 (authorizing a protocol on biosafety).

34. *The Cartagena Protocol on Biosafety*, CONVENTION ON BIOLOGICAL DIVERSITY, http://bch.cbd.int/protocol/ (last updated Sept. 26, 2014).

35. *Id.*

36. Cartagena Protocol on Biosafety to the Convention on Biological Diversity arts. 7–10, 15, Jan. 29, 2000, 39 I.L.M. 1027.

37. *Id.* at art. 11.

38. *See, e.g.*, Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, Mar. 22, 1989, 1673 U.N.T.S. 126; Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, Sept. 10, 1998, 2244 U.N.T.S. 337.

39. Cartagena Protocol on Biosafety to the Convention on Biological Diversity, *supra* note 36, at art. 20.

40. Nagoya-Kuala Lumpar Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety, Oct. 16, 2010.

Union, Australia, Canada, and Japan. Differences between the United States' regulatory approach and that of the European Union underlaid much of the tension in the negotiation of the Biosafety Protocol and ultimately resulted in a major trade dispute between these two powers.[41]

Beginning in 1986, the European Union took the position that bioengineered crops and foods inherently differed from their conventional counterparts and necessitated new and special regulations.[42] In 1988, the European Commission proposed a multi-layered prior approval and risk assessment process for bioengineered goods intended for release into the environment.[43] The European Parliament criticized the proposal as too lax and in 1990, the European Union adopted a stricter directive.[44] The EU tightened its control over bioengineered foods even further in 1997 and again in 2003. It now required pre-market approval not only of GMO foods but also of foods produced from GMOs that no longer contained any GM material, such as processed oils.[45] It also mandated the labeling of foods containing GMOs,[46] as well as the labeling of GMO feed and refined products derived from GMOs, even if these products lack any detectable amounts of GM DNA or proteins.[47]

Like the European Union, the United States first tackled the regulation of biotechnology in 1986.[48] Unlike the European Union, the United States decided that biotechnology was not inherently risky. It determined that existing agencies under existing statutes could regulate biotechnology and that regulation and oversight should be based on assessing the safety of the

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41. The United States requested the formation of a WTO dispute-settlement panel in August of 2003. The panel was formed in March of 2004. Panel Report, *European Communities—Measures Affecting the Approval and Marketing of Biotech Products*, WT/DS291/R (Sept. 29, 2006).

42. COMM'N OF THE EUROPEAN COMMUNITIES, A COMMUNITY FRAMEWORK FOR THE REGULATION OF BIOTECHNOLOGY (1986); *see also* MARK A. POLLACK & GREGORY C. SHAFFER, WHEN COOPERATION FAILS: THE INTERNATIONAL LAW AND POLITICS OF GENETICALLY MODIFIED FOODS 60 (2009) (describing the European Commission's position).

43. POLLACK & SHAFFER, *supra* note 42, at 60.

44. *Id.* at 61.

45. Regulation (EC) No 258/97 of the European Parliament and of the Council of 27 January 1997 Concerning Novel Foods and Novel Food Ingredients, 1997 O.J. (L 43) 1–6.

46. *Id.*

47. Commission Regulation 183/2003, 2003 O.J. (L 27) 6 (EC); PEW INITIATIVE ON FOOD AND BIOTECHNOLOGY, U.S. VS. EU AN EXAMINATION OF THE TRADE ISSUES SURROUNDING GENETICALLY MODIFIED FOOD 5 (2005).

48. *See* Coordinated Framework for Regulation of Biotechnology, 51 Fed. Reg. 23,302 (June 26, 1986); Statement of Policy: Foods Derived from New Plant Varieties, 57 Fed. Reg. 22,984 (May 29, 1992).

products of biotechnology rather than the *process* by which they were made.[49]

Just as it reviews the safety of all pesticides for human consumption, the Environmental Protection Agency ("EPA") reviews for safety for human consumption all GMOs with pesticide qualities, such as *Bt* corn. The Food and Drug Administration ("FDA") requires pre-market approval for genetically modified foods if the genetic manipulation has altered the substance or the safety of the product by creating, for example, new allergenic properties or a toxin or changing the nutritional content of the food.[50] Other genetically-modified foods fall within FDA's voluntary approval system.[51] Even if they are not required to, companies avail themselves of this system.[52] Although the U.S. system is less strict than the European one, it appears that companies do not put bioengineered food on the U.S. market without some kind of regulatory nod. Unlike the European Union, the United States does not require the labeling of genetically modified foods.[53]

As a matter of international law and the domestic laws of approximately ninety nations, including the United States, the release of genetically modified organisms into the environment requires an environmental risk assessment and government approval before such release.[54] In addition, over eighty countries regulate genetically modified organisms intended for food, feed or processing.[55]

As discussed below, the Flavr Savr tomato, with its flipped gene, presented no risk to the environment or to human health. Amidst protests to

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49. *See id.*

50. Statement of Policy: Foods Derived from New Plant Varieties, 57 Fed. Reg. at 22,993.

51. *See id.* at 22,985; 21 C.F.R. § 170.35 (2003).

52. Gregory N. Mandel, *Gaps, Inexperience, Inconsistencies, and Overlaps: Crisis in the Regulation of Genetically Modified Plants and Animals*, 45 WM. & MARY L. REV. 2167, 2220 (2004); Andrew Pollack, *U.S.D.A. Ruling on Bluegrass Stirs Cries of Lax Regulation*, N.Y. TIMES, July 7, 2011, at B2 (quoting Stanley H. Abramson, a lawyer for biotechnology companies: "genetically engineered food crops would not be accepted by the market without government approval. So only developers of non-edible plants like grass or flowers might try to exempt themselves from regulation.").

53. *Id.*

54. *See Second National Report Analyzer*, BIOSAFETY CLEARING-HOUSE, http://bch.cbd.int/database/reports/results (last visited Sept. 25, 2014) (of the 150 out of 163 parties surveyed, eighty-seven report that they have established domestic regulations for the intentional introduction into the environment of genetically modified organisms (question 30), eighty-five report that they have implemented the Protocol's advanced informed agreement system, (question 29) and ninety-seven have established a mechanism for conducting risk assessments (question 81)). For more on the regulation of biotechnology in the developing world, see ROBERT L. PAARLBERG, THE POLITICS OF PRECAUTION: GENETICALLY MODIFIED CROPS IN DEVELOPING COUNTRIES (2001).

55. *Second National Report Analyzer*, *supra* note 54.

bioengineered food, grocers stopped selling paste made from the tomatoes. Today, one cannot find the Flavr Savr Tomato for sale anywhere in the world.[56]

C. Legal Response to the Cellphone

In contrast to agricultural biotechnology, governments around the world have taken few steps to regulate cellphones domestically. They have taken no steps to regulate cellphones internationally. The primary international response to cellphones has been the conduct of studies.

In May of 1994, the European Union Parliament took its first action on the potential harmful effects of the cellphone**.** It called on the European Commission to propose legislative measures to limit the exposure of workers and the public to non-ionizing electromagnetic radiation.[57] The European Union Council did not act for five years. Finally, in July of 1999, it issued a non-binding recommendation to the European Union member states suggesting that they limit their citizens' exposure level to electromagnetic frequencies.[58] The "Specific Absorption Rate" or SAR measures the rate at which the human body absorbs radiation. The Council recommended that European nations restrict the sale of cellphones whose SAR exceeds 2 Watts per kilogram, averaged over a volume of 10 grams of tissue.[59] This tracks the SAR limit for brain tissue recommended in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).[60] In 2008, the European Commission reported that most EU states had adopted the July 1999 limitations.[61] The European Parliament revisited the issue of cellphone

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56. A genetically-modified cherry tomato developed in Israel is grown in Mexico.

57. Council Recommendation on the Limitation of Exposure of the General Public to Electromagnetic Fields (0 Hz to 300 GHz), 1999 O.J. (L 199) 59.

58. *Id.*

59. *Id.*

60. LLOYD'S EMERGING RISKS TEAM, ELECTRO-MAGNETIC FIELDS FROM MOBILE PHONES: RECENT DEVELOPMENTS (2010), *available at* http://www.lloyds.com/The-Market/Tools-and-Resources/Research/Exposure-Management/Emerging-risks/Emerging-Risk-Reports/Health/EMF; INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION, ICNIRP GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC AND ELECTROMAGNETIC FIELDS (UP TO 300 GHZ) (1998), *available at* http://www.icnirp.de/PubEMF.htm; KLEMENS, *supra* note 13 at 150.

61. *Report from the Commission on the Application of Council Recommendation of 12 July 1999 (1999/519/EC) on the Limitation of the Exposure of the General Public to Electromagnetic Fields (0 Hz to 300 GHz)*, at 5, COM (2008) 532 final (Sept. 1, 2008).

radiation in April 2009.[62] It noted that the scientific dispute over the safety of cellphone radiation had intensified since 1999 and that more people, including children, were using cellphones.[63] It refrained, however, from taking any action.

The United States acted earlier. In August of 1996, the Federal Communications Commission required that hand-held cellular phones have a SAR of no more than 1.6 watts per kilogram averaged over one gram of tissue for the brain and 4.0 watts per kilogram averaged over any 10 grams of tissue for other parts of the body like the hand or the ear.[64] Some say that the U.S. regulation is stricter than the EU limits.[65] Others maintain that one cannot compare the restrictions given the different volume averages.[66]

China ostensibly regulated cellphone emissions first. Its earliest rules date back to the late 1980s.[67] China limits SAR rates to .02 watts per kilogram, averaged over the total body as opposed to the contact area.[68] According to Lloyd's, as of 2010, approximately eighty nations worldwide have adopted ICNIRP guidelines, which limit exposure to 2W per kilogram.[69] Many nations, such as India (as of August 2010), have yet to adopt limits, even as their populations' use of cellphones soar.[70] No nation requires even the simplest of precautionary safety measures—that cellphones come with headsets, much as cars come with seatbelts.

While the European Union, Australia, Japan and Korea mandate the labeling of bioengineered foods and the Biosafety Protocol contemplates some labeling,[71] no nation requires that labels accompany cellphones to indicate how much SAR they emit. Consumers, therefore, cannot readily incorporate this information when purchasing cellphones. Similarly, no

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62. European Parliament Resolution of 2 April 2009 on Health Concerns Associated with Electromagnetic Fields, EUR. PARL. DOC. (2008/2211(INI)) (2009).

63. *Id.*

64. Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, 47 C.F.R. § 2.1093 (1996); *see also* KLEMENS, *supra* note 13, at 149; Laura Grasso, *Cellular Telephones and the Potential Hazards of RF Radiation: Responses to the Fear and Controversy*, 3 VA. J.L. & TECH. 2, 13–14 (1998).

65. KLEMENS, *supra* note 13, at 149–50.

66. LLOYD'S EMERGING RISKS TEAM REPORT, *supra* note 60, at 5.

67. World Health Organization (WHO), Int'l Electromagnetic Fields Project, *Electromagnetic Fields (EMF) Protection - China*, http://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Asia/China_files/table_ch.htm (last updated March 3, 2004).

68. *Id.*

69. LLOYD'S EMERGING RISKS TEAM REPORT, *supra* note 60, at 5.

70. *See* Sandeep Joshi, *Stricter Guidelines Soon for Mobile Radiation*, HINDU (Aug. 9, 2010), http://www.thehindu.com/news/national/article559504.ece.

71. Cartagena Protocol on Biosafety to the Covention on Biological Diversity, *supra* note 36, at art. 18.

nation requires that cellphones come with labels indicating that parents limit the use of cellphones by children, that customers use headsets, or that men refrain from keeping cellphones in their front pant pockets to avoid damaging sperm. Many cellphones have small print warnings buried in their instruction manuals improbably advising customers to hold the cellphone one inch away from their head and to keep the phone away from their bodies.

The discrepancy between the strict labeling requirements for bioengineered food and no labeling for cellphones is even more perplexing when one considers cost. Labeling bioengineered food necessitates the segregation of the food supply between bioengineered grain and traditional varieties. It is, therefore, quite expensive,[72] potentially increasing costs by twenty-five percent or more.[73] Unlike grains, cellphones are not co-mingled during production or distribution. Cellphone packaging could easily display SAR levels as well as a few recommended safety measures. Both cellphone producers and GMO food producers oppose labels on the ground that labels suggest that their products are unsafe, provide information of little or no use, and will dampen sales.[74] Despite the similar nature of the concerns, many countries require labels on GMO foods but do not require them on cellphones.

If anything, the response by nations and the international community to the cellphone has been to facilitate rather than to regulate it. In the mid-1990s, while the groundwork for the Biosafety Protocol was being laid, the International Telecommunications Union (ITU), a UN specialized agency, sought to facilitate the development of the next generation of cellphones. It did so by indicating which cellphone standards to admit into usage and by encouraging more uniform operating standards around the world.

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72. POLLACK & SHAFFER, *supra* note 42, at 156 n.175 (citing Nicholas Kalaitzandonakes, *Cartagena Protocol: A New Trade Barrier*, 29 REG. 18, 18–25 (2006)).

73. *Id.* (citing Richard Stewart, The GMO Challenge to International Environmental Trade Regulation: Developing Country Perspectives (unpublished draft) (on file with POLLACK & SHAFFER).

74. *See* Andrew Pollack, *F.D.A. Hearing Focuses on the Labeling of Genetically Engineered Salmon*, N.Y. TIMES, Sept. 22, 2010, at B3; Chloe Albanesius, *CTIA Sues San Francisco over Cellphone Radiation Labeling Law*, PCMAG.COM (July 23, 2010), http://www.pcmag.com/article2/0,2817,2366934,00.asp; Kendra Srivastava, *Cellphone Radiation Law Delayed Indefinitely in San Francisco*, DAILY CELLPHONE NEWS BLOG (May 6, 2011), http://daily-cellphones-news.blogspot.com/2011/05/cell-phone-radiation-law-delayed-for.html.

II. EXPLAINING THE DIFFERENCE—BENEFITS, RISKS AND THEORIES

A. Benefits

While the Flavr Savr tomato was undergoing strenuous regulatory review and the international community was revving up for a major and unprecedented treaty negotiation, the cellphone was moving through the domestic and the international legal capillaries largely unhindered. When asking why did agricultural biotechnology engender universal concern while the cellphone encounter universal acceptance, two answers spring to mind. First, we love our cellphones and we care little about bioengineered grains. Cellphones provide us with tangible benefits in a way that bioengineered foods do not. Many have noted that first generation bioengineered foods benefited farmers rather than providing ostensible benefits to consumers.

While true, this easy answer does not explain the diametrically different legal paths that these twin technologies took. As shown above, the movement to regulate agricultural biotechnology and to refrain from regulating the cellphone took place years before the planting of any bioengineered crops and when few consumers had cellphones. In the late 1980s and through most of the 1990s, the average consumer could hardly afford the cellphone, which originally cost $3,995.[75] The cellphone served as a business tool or a gadget for the rich. Furthermore, the panoply of benefits that the cellphone provides us with today was not so apparent in the past. AT&T, for example, originally decided not to pursue mobile phone technology because it did not see a large market for it.[76]

Finally, the issue in most cases is not whether to ban an emerging technology but whether and to what extent to regulate it. Cellphones could still have penetrated the market but with regulations that would require, for example, that they be sold with headsets, that they have labels that identify handset emissions, and that they advise safe use practices. In sum, when the cellphone and the Flavr Savr tomato first emerged from the primordial technological muck and before few people enjoyed, let alone knew of, the benefits of the twin technologies, the two technologies found themselves on very different legal paths. These divergent paths persist today.

The second explanation is risk. Perhaps agricultural biotechnology is risky and the cellphone is not, or at least is less risky than agricultural biotechnology.

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75. DAVIS, *supra* note 8, at 41; KLEMENS, *supra* note 13, at 69.
76. DAN STEINBOCK, THE NOKIA REVOLUTION 112 (2001).

B. Risks of Agricultural Biotechnology

1. Risks to Human Health

Before bringing its new wonder tomato to market, Calgene sought regulatory approval from the United States Food and Drug Administration. On November 26, 1990, it filed a massive document requesting that the agency find that the altered gene at the core of its tomato was safe for human consumption.[77] Thus began an exhaustive four-year review of the tomato's safety.

Bioengineered food presents a host of potential risks to human health. First, bioengineered food might trigger an allergic reaction.[78] For example, were a tomato genetically-modified to contain the gene of a peanut, people allergic to peanuts could react to the tomato.[79] Second, in altering a food's genetic make-up, scientists might unwittingly reduce the food's nutritional value.[80] Experiments showed that the Flavr Savr tomato was not an allergen and retained the vitamin and mineral levels normally found in tomatoes.[81]

A third concern involved whether Calgene might have unintentionally created a toxic tomato.[82] Calgene force-fed rats excessive quantities of Flavr Savr tomato puree to see if the new tomatoes proved toxic. They did not.[83] Toxicity concerns arise as well with crops bioengineered to resist pests. Organic farmers and home gardeners have long used a common soil bacterium, *bacillus thruingiensis* or *Bt*, as a spray-on insecticide.[84] Genes from the *Bt* bacterium have been transferred to potatoes, corn and cotton.[85] The EPA conducted acute toxicity tests on these crops and found them non-toxic.[86] After six years of review, the Government of the Philippines similarly approved *Bt* corn for release in its nation.[87] It determined that *Bt* corn did not harm humans because the *Bt* protein only affects organisms with specific

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77. MARTINEAU, *supra* note 18, at 90.
78. PETER PRINGLE, FOOD INC. 60 (2003).
79. *Id.*
80. MARTINEAU, *supra* note 18, at 113–14.
81. *Id.* at 116–22, 145, 154, 156 and 186.
82. *Id.* at 115–16.
83. *Id.* at 116–17.
84. KLEINMAN, *supra* note 6, at 24.
85. *Id.*
86. ENVTL. PROTECTION AGENCY (EPA), BT PLANT-INCORPORATED PROTECTANTS OCTOBER 15, 2001 BIOPESTICIDES REGISTRATION ACTION DOCUMENT IIB4–IIB35 (2001), *available at* http://www.epa.gov/oppbppd1/biopesticides/pips/bt_brad2/2-id_health.pdf.
87. Marvin Vicedo, *The Safety of BT Corn*, FOODRECAP.NET (July 30, 2010), http://www.foodrecap.net/safety/safety-bt-corn/.

receptor sites in their alkaline guts where the proteins can bind.[88] Human beings lack these receptors and have acidic rather than alkaline stomachs.[89] Any toxicity of *Bt* crops must be balanced against the reduction, if not the elimination, of spray-pesticide residue which they enable.[90]

A fourth concern involves unintended and unanticipated consequences of genetic manipulation. The science is less precise than its proponents would have people believe. For example, genes for the color red inserted into petunias not only made the plants redder but unexpectedly decreased their fertility and altered their growth.[91] Salmon genetically-engineered to grow faster, "not only grew too big too fast but also turned green."[92] At the FDA's insistence, Calgene conducted a study to look for any unanticipated or unexpected consequences of its genetic manipulation and ultimately found none.[93] The EPA has conducted extensive, albeit short-term, tests on *Bt* crops and found no adverse health impacts.[94]

2. Risks to the Environment

Bioengineered food presents a number of risks to the environment. The first is unintended gene flow, which can have unintended and unpredicted environmental effects.[95] Genetically-enhanced crops, for example, may crossbreed with weedy relatives and unwittingly create superweeds.[96] They might also crossbreed with their wild relatives such that some wild plants may no longer exist without unwanted modified genetic traits.[97]

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88. *Id.*

89. EPA, *supra* note 86.

90. Food and Agric. Org. of the U.N., *The State of Food and Agriculture 2003–04*, 76 (2004) (describing decline in pesticide use as a result of bioengineered crops); David Pimentel, *Overview of the Use of Genetically Modified Organisms and Pesticides in Agriculture*, 9 IND. J. GLOBAL LEGAL STUD. 51, 58 (2001–2002) ("In the United States, approximately thirty-five percent of all foods in supermarkets have detectable pesticide residues, and at least one to three percent of all foods have residues above the Food and Drug Administration's acceptable tolerance level.").

91. MARTIN TEITEL & KIMBERLY A. WILSON, GENETICALLY ENGINEERED FOOD: CHANGING THE NATURE OF NATURE 12 (Park Street Press 2d ed. 2001).

92. *Id.*

93. MARTINEAU, *supra* note 18, at 150–53.

94. Mandel, *supra* note 52, at 2192; NAT'L RESEARCH COUNCIL, GENETICALLY MODIFIED PEST-PROTECTED PLANTS: SCIENCE AND REGULATION 65 (2000) ("Information in peer reviewed studies indicates plant-expressed Bt Proteins are probably without human health risk.").

95. *See, e.g.*, Andrew Pollack, *Genes from Engineered Grass Spread for Miles, Study Finds*, N.Y. TIMES, Sept. 21, 2004, at A1.

96. Claire Hope Cummings, *Trespass*, WORLD WATCH, Jan.–Feb. 2005, at 30.

97. *Id.*

Genetically-engineered crops may also cross-breed with conventional varieties, causing economic loss to organic farmers and traditional breeders who want to continue producing unmodified food.[98] The Union of Concerned Scientists reported that "low levels of DNA originating from engineered varieties of" corn, soybeans, and canola "now pervasively contaminate[]" traditional varieties of these crops.[99] In July of 2011, Bayer agreed to pay $750 million to settle claims with some 11,000 farmers whose rice was tainted with trace amounts of Bayer's experimental genetically-modified rice.[100] This caused the farmers to lose exports to the European Union, Japan, and Russia and occasioned a $150 million decline in the value of their rice futures.[101] In addition, genetically-altered plants or fish may turn out to be invasive species.

3. Conclusion

Despite the *potential* health risks, there are no documented negative health effects attributed to consuming bioengineered food.[102] According to Nina Federoff, who served as the science and technology adviser to former Secretary of State Condoleezza Rice, the European Union has spent over $425 million over the past twenty-five years studying the safety of genetically-modified crops.[103] A lengthy report issued in 2010 by the European Commission Directorate General for Research and Innovation sums up the findings:

> The main conclusion to be drawn from the efforts of more than 130 research projects, covering a period of more than 25 years of research, and involving more than 500 independent research groups,

98. *Id.*

99. Pollack, *supra* note 95.

100. Bloomberg News, *Bayer Settles with Farmers Over Modified Rice Seeds*, N.Y. TIMES, July 2, 2011, at B7.

101. *Id.*

102. NAT'L RESEARCH COUNCIL, SAFETY OF GENETICALLY ENGINEERED FOODS: APPROACHES TO ASSESSING UNINTENDED HEALTH EFFECTS 8 (2004) ("To date, no adverse health effects attributed to genetic engineering have been documented in the human population."); Suzie Key, Julian K-C Ma & Pascal MW Drake, *Genetically Modified Plants and Human Health*, 101 J. ROYAL SOC'Y MED. 290, 292–93 (2008) (GM foods have been eaten by millions of people worldwide for over 15 years with no reports of ill effects).

103. Nina V. Fedoroff, Op-Ed., *Engineering Food for All*, N.Y. TIMES, Aug. 19, 2011, at A23.

> is that biotechnology, and in particular GMOs, are not *per se* more risky than e.g. conventional plant breeding technologies.[104]

A 2009 report commissioned by the European Union reaches the same conclusion.[105]

As for the environmental impacts of bioengineered food, because bioengineered crops largely form an alternative to damaging pesticides and herbicides, their net effect on the environment may be positive rather than negative. A major study by the UN Food and Agriculture Organization concludes:

> Thus far, in those countries where transgenic crops have been grown, there have been no verifiable reports of them causing any significant health or environmental harm. . . . On the contrary, some important environmental and social benefits are emerging. Farmers are using less pesticide and are replacing toxic chemicals with less harmful ones. As a result farm workers and water supplies are protected from poisons, and beneficial insects and birds are returning to farmers' fields.[106]

Indeed, according to one study, the planting of genetically modified crops reduced pesticide use by forty-six million pounds in 2001 alone.[107] Another study estimated that GM crops reduced global pesticide use by 286,000 tons in 2006.[108] Unlike spray-on pesticides, which kill a broad-spectrum of insects,

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104. European Comm., Directorate-Gen. for Research and Innovation Biotechnologies, Agric., Food, *A Decade of EU-funded GMO Research (2001-2010)* 16 (2010).

105. Fed. Office of Consumer Prot. and Food Safety, *Long-term Effects of Genetically Modified Crops on Health and on the Environment* at 77–80 (2009), *available at* http://ec.europa.eu/food/food/biotechnology/reports_studies/docs/lt_effects_report_en.pdf (EU report concludes that genetically-modified crops are no more dangerous to animal or human health than their conventional counterparts but notes that future generation GMO crops with more modified traits may present new allergenicity concern). *See* Federoff, *supra* note103, at A23 (noting that the National Academy of Sciences and the British Royal Society have similarly concluded that crop modification by biotechnology is no more dangerous than crop modification by other methods. *See also* HENRY I. MILLER & GREGORY CONKO, THE FRANKENFOOD MYTH (2004). *But see*, JEFFREY M. SMITH, GENETIC ROULETTE: THE DOCUMENTED HEALTH EFFECTS OF GENETICALLY ENGINEERED FOODS 150–157 (2007).

106. Food and Agric. Org. of the U.N., *supra* note 90, at 76.

107. Mandel, *supra* note 52, at 2183; *see also* LEONARD P. GIANESSI ET AL., PLANT BIOTECHNOLOGY: CURRENT AND POTENTIAL IMPACT FOR IMPROVING PEST MANAGEMENT IN U.S. AGRICULTURE 55 (2002). According to one estimate, of the 8.1 billion dollars spent annually on insecticides worldwide, almost 2.7 billion dollars could be saved by using BT crops instead. *See* PRINGLE, *supra* note 78, at 123. *See generally* GRAHAM BROOKES & PETER BARFOOT, GM CROPS: THE FIRST TEN YEARS—GLOBAL SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS 36 (2006).

108. Graham Brookes & Peter Barfoot, *Global Impact of Biotech Crops: Socio-Economic and Environmental Effects,* 11 AGBIOFORUM 21, 26 (2008).

genetically-engineered plants target specific insects.[109] Herbicide-resistant GMO crops, like Round-up Ready Soybean and Cotton, require less tillage. This reduces agriculture's carbon footprint, with some estimating the reduction equivalent to removing 3.58 million cars from the roads.[110] It also creates less soil erosion and depletion of soil nutrients, and decreases water loss.[111]

On the other hand, herbicide-resistant crops may cause farmers to increase their use of herbicides because they no longer fear losing their crops to these poisons.[112] Moreover, because pest-resistant plants manifest the pesticide throughout the growing season, their presence in the soil may exceed that of their spray-on counterparts.[113] Concern has arisen that certain bugs or weeds may develop resistance to *Bt* or herbicides, but it is unclear whether the risk of developing such resistance is greater than would occur from spray-on insecticides and herbicides.

The concern that bioengineered organisms will become invasive species has yet to materialize. This risk, however, looms larger with the advent of genetically-engineered fish.[114] Overall, unintended gene flow likely represents biotechnology's greatest risk to the environment—the complete consequences of which have yet to become fully manifest or fully appreciated.

C. Risks of the Cellphone

1. Risks to Human Health

Cellphones transmit signals via radio waves, a form of electromagnetic radiation. Electromagnetic radiation can be either ionizing or non-ionizing. Ionizing radiation, like that emitted by x-ray machines and power lines, has sufficient strength to break molecular bonds and directly damage DNA.

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109. Mandel, *supra* note 52, at 2184–85.

110. Brookes & Barfoot, *supra* note 108, at 83.

111. Michele C. Marra et al., *The Net Benefits, Including Convenience, of Roundup Ready Soybeans: Results from a National Survey*, NSF CTR. FOR INTEGRATED PEST MGMT., Sept. 2004, at 2 (Indiana study reported marked reduction in tillage by farmers who adopted Round-Up-Ready Soybean and that such farmers use Round-Up-Ready largely because of its health advantages to the farmers and to the environment over spray-on herbicides.); Mandel, *supra* note 52, at 2185.

112. Mandel, *supra* note 52, at 2198.

113. Marra, *supra* note 111, at 2197.

114. *See* Pollack, *supra* note 74, at B3; *see also* Mandel, *supra* note 52, at 2200, 2208; *see generally* NAT'L RESEARCH COUNCIL, BIOLOGICAL CONFINEMENT OF GENETICALLY ENGINEERED ORGANISMS (2004).

Prolonged exposure to ionizing radiation has been linked to cancer. Cellphones emit non-ionizing radiation, which is considerably weaker and less dangerous. The issue is whether extended exposure to cellphones' non-ionizing radiation damages human health.

Turning to the big question first: Do cellphones cause cancer? The evidence is far from conclusive, but suggests that extended cellphone use may increase the risk of the brain cancer glioma and of acoustic neuroma.[115] For some years, regulators largely maintained that scientists had not found a link between cellphones and cancer.[116] Three studies published between 2000–2002 did not establish a correlation between cancer and cellphone use.[117] These early studies, however, covered a period of minimum mobile phone use when users typically had low cumulative exposures.[118] An important study in Denmark surveyed 420,095 cellphone subscribers from 1982 through 1995 and compared these users with the Danish Cancer Registry. The study, which was published in 2001 and updated in 2006 and 2011, showed no increase in cancer among these early cellphone subscribers.[119] Like the other early studies, however, it spanned a period of low volume cellphone use. The weekly average length of outgoing calls was only 23 minutes for subscribers in 1987–95 and a mere 17 minutes in 1996–2002.[120]

While encouraging news was coming out of Denmark, beginning in 1999, researchers in Sweden led by Dr. L. Hardell were discovering and publishing more troubling signs. Dr. Hardell and his team have conducted four studies[121]

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115. ENVTL. WORKING GROUP, CELLPHONE RADIATION SCIENCE REVIEW ON CANCER RISKS AND CHILDREN'S HEALTH 1, 8 (2009), *available at* http://static.ewg.org/reports/2009/CellPhoneRadiation_ScienceReview_2009.pdf.

116. *Id.*

117. *See generally* Anssi Auvinen et al., *Brain Tumors and Salivary Gland Cancers Among Cellular Telephone Users*, 13 EPIDEMIOLOGY 356 (2002); Peter D. Inskip et. al., *Cellular-Telephone Use and Brain Tumors*, 344 (2) NEW ENG. J. MED. 79 (2001); Joshua E. Muscat et al., *Handheld Cellular Telephone Use and Risk of Brain Cancer*, 284 (23) JAMA 3001 (2000).

118. Robert Baan et al. on behalf of the WHO International Agency for Research on Cancer, *Carcinogenicity of Radiofrequency Electromagnetic Fields*, 12 LANCET ONCOLOGY 624, 625 (2011).

119. Patrizia Frei et al., *Use of Mobile Phones and Risk of Brain Tumours: Update of the Danish Cohort Study*, 343 BRITISH MED. J. 1, 1 (2011) [hereinafter 2011 Danish Update]; Christoffer Johansen, et al., *Cellular Telephones and Cancer–A Nationwide Cohort Study in Denmark*, 39 J. NATL. CANCER INST. 203, 203–07 (2001); J. Schüz et al., *Cellular Telephone Use and Cancer risk: Update of a Nationwide Danish Cohort*, 98 J. NATL. CANCER INST. 1707, 1707–13 (2006).

120. Frei et al., 2011 Danish Update, *supra* note 119, at 4.

121. Lennart Hardell et al., *Case-control study on Cellular and Cordless Telephones and the Risk for Acoustic Neuroma or Meningioma in Patients Diagnosed 2000–2003*, 25 NEUROEPEDEMIOLOGY 120, 120–28 (2005); Lennart Hardell et al., *Case-control study of the Association Between the Use of Cellular and Cordless Telephones and Malignant Brain Tumors*

and five analyses that pool their data of brain tumors diagnosed between 1997 and 2003.[122] Their May 2011 analysis reported a 170% increase in the most common type of brain cancer, astrocytoma glioma, for those who have used cellphones for more than ten years.[123] Those who first used cellphones before the age of twenty had an almost 400% increased risk of glioma.[124] Another group's recent meta-analysis of the cancer risk of cellphones found an almost doubling of the risk of head tumors, including brain tumors, tumors of the acoustic nerve and tumors of the salivary gland.[125]

Concern that cellphones might cause brain cancer prompted the World Health Organization International Agency for Research on Cancer (IARC) to launch a major study in 2000 called the Interphone Study. The study involved thirteen industrialized countries (Australia, Canada, Denmark, Finland, France, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden, and the United Kingdom) and thousands of participants. It compared the occurrence of two types of brain tumors diagnosed between 2000–2004 in those who used cellphones and those that did not. In May of 2010, it issued its long-awaited report. It found an approximately forty percent increase in the risk for the lethal brain tumor glioma and an approximately fifteen percent increase in risk for the generally non-lethal brain tumor meningioma for those

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Diagnosed Between 2000–2003, 100 ENVTL. RES. 232, 232–41 (2006); Lennart Hardell et al., *Further Aspects on Cellular and Cordless Telephones and Brain Tumours*, 22 INT'L J. OF ONCOLOGY 399, 399–407 (2003); Lennart Hardell et al., *Tumour Risk Associated with Use of Cellular Telephones or Cordless Desktop Telephones*, 4 WORLD J. SURGICAL ONCOLOGY 74, 74 (2006); *see also* Lennart Hardell et al., *Use of Cellular Telephones and the Risk for Brain Tumours: A Case Control Study*, 15 INT'L J. OF ONCOLOGY 113, 113–16 (1999).

122. Lennart Hardell et al., *Pooled Analysis of Two Case-Control Studies on the Use of Cellular and Cordless Telephones and the Risk of Benign Brain Tumours Diagnosed During 1997–2003*, 28 INT'L J. OF ONCOLOGY 509, 509–18 (2006); Lennart Hardell et al., *Pooled Analysis of Two Case-Control Studies on the Use of Cellular and Cordless Telephones and the Risk for Malignant Brain Tumours Diagnosed in 1997–2003*, 79 INT'L ARCHIVES OF OCCUPATIONAL AND ENVTL. HEALTH 630, 630–39 (2006); Lennart Hardell & Michael Carlberg, *Mobile Phones, Cordless Phones and the Risk for Brain Tumors*, 35 INT'L J. OF ONCOLOGY 5, 5–17 (2009).

123. Lennart Hardell et al., *Pooled Analysis of Case-Control Studies on Malignant Brain Tumours and the Use of Mobile and Cordless Phones Including Living and Deceased Subjects*, 38 INT'L J. OF ONCOLOGY 1465, 1465–74 (2011).

124. *Id.* For a critique of the Hardell studies, see Anders Ahlbom et al., *Epidemiologic Evidence on Mobile Phones and Tumor Risk: A Review*, 20 EPIDEMIOLOGY 639, 639 (2009). A Finnish study showed 100% increase in the risk for glioma among cellphone users. Ansi Auvinen et al., *Brain Tumors and Salivary Gland Cancers Among Cellular Telephone Users*, 13 EPIDEMIOLOGY 356, 357 (2002).

125. Angelo G. Levis et al., *Mobile Phones and Head Tumours. The Discrepancies in Cause-Effect Relationships in the Epidemiological Studies - How Do They Arise?*, 10 ENVTL. HEALTH 1, 1 (2011); *see also* Michael Kundi, *The Controversy about a Possible Relationship between Mobile Phone Use and Cancer*, 117 ENVTL. HEALTH PERSP. 316, 316 (2009).

with the highest level of cellphone use.[126] It defined this high-use group as people who used a cellphone for more than ten years, with a cumulative talk time that averaged twenty-seven minutes a day. It discovered no overall increase in the occurrence of these cancers among those with lower cellphone use.[127] Recall biases of the subjects as well as some errors in the results, which showed that those with modest cellphone use improbably had lower rates of brain cancer than those who did not use cellphones at all, prevented the IARC at that time from concluding that cellphone use causes cancer.[128]

A year later, in May of 2011, a Working Group of thirty-one scientists from fourteen countries met at the IARC. The group reviewed hundreds of scientific articles, including the Interphone Study, individual country reports, the Danish study, and the Hardell studies. It decided to classify radiofrequency magnetic fields of the kind emitted by cellphones as *possibly* carcinogenic to humans (Group 2B). This puts them in the same category as lead, chloroform, and coffee. It did so based on an increased risk for glioma and acoustic neuroma.[129] For all other cancers, it reached no conclusion.[130] The Working Group drew attention to particular risks for children, noting that children's brains absorb double the radiofrequency energy as those of adults and ten times more energy than adults in the bone marrow of their skulls.[131] A few members of the Working Group as well as others object to the upgrading of cellphone radiation as possibly carcinogenic, considering the current evidence in humans "inadequate" for such a finding.[132]

126. Press Release, International Agency for Research on Cancer, WHO, Press Release No. 200: Interphone Study Reports on Mobile Phone Use and Brain Cancer Risk (May 17, 2010), http://www.iarc.fr/en/media-centre/pr/2010/pdfs/pr200_E.pdf.

127. *Id.*

128. *Id.*

129. Press Release, International Agency for Research on Cancer, WHO, Press Release No. 208: IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic to Humans (May 31, 2011), http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf.

130. Baan et al., *supra* note 118, at 625.

131. *Id.*

132. *Id.*; *see also* Anthony J. Swerdlow et al., *Mobile Phones, Brain Tumors, and the Interphone Study: Where Are We Now?*, 119 ENVTL. HEALTH PERSP. 1534, 1534 (2011); Ben Hirschler, *Danish Study: Mobile Phones Don't Hike Cancer Risk*, REUTERS, Oct. 22, 2011, *available at* http://www.reuters.com/article/2011/10/21/us-phones-cancer-idUSTRE79K0XI20111021.

Cellphones pose potential health risks other than cancer. These include damaging sperm,[133] adversely affecting sleep,[134] compromising cognitive functions,[135] and doubling the risk of tinnitus (ringing of the ear).[136] Scientists recently discovered that cellphones increase the metabolic activity of the brain tissue closest to the antenna, rather than simply heating the tissue, as earlier believed. They do not know the clinical significance of this finding.[137]

2. Risks to the Environment

While consensus does not exist on the health effects of using the cellphone, cellphones clearly damage the environment. Cellphones contain materials that, when released, are toxic to animals, plants, and humans. These include lead, beryllium, arsenic, mercury, antimony and cadmium.[138] The

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133. Ashok Agarwal et al., *Effects of Radiofrequency Electromagnetic Waves (RF-EMW) from Cellular Phones on Human Ejaculated Semen: An in Vitro Pilot Study*, 92 FERTILITY & STERILITY 1318, 1318 (2009); I. Fejes et al., *Is There a Relationship Between Cellphone Use and Semen Quality?*, 51 ARCHIVES ANDROLOGY 385, 385 (2005); s*ee also* Geoffry N. De Iuliis et al., *Mobile Phone Radiation Induces Reactive Oxygen Species Production and DNA Damage in Human Spermatozoa* In Vitro, 4 PLOS ONE 1, 1 (2009); A. A. Otitoloju et al., *Preliminary Study on the Induction of Sperm Head Abnormalities in Mice,* Mus musculus*, Exposed to Radiofrequency Radiations from Global System for Mobile Communication Base Stations*, 84 BULL. ENVTL. CONTAMINATION & TOXICOLOGY 51, 51 (2009).

134. *See, e.g.*, Alexander A. Borbély et al, *Pulsed High Frequency Electromagnetic Field Affects Human Sleep and Sleep Electroencephalogram*, 275 NEUROSCIENCE LETTERS 207, 207 (1999); Reto Huber et al., *Electromagnetic Fields, Such as Those From Mobile Phones Alter Regional Cerebral Blood Flow and Sleep and Waking EEG*, 11 J. SLEEP RES. 289, 289 (2002); Reto Huber et al., *Exposure to Pulsed High Frequency Electromagnetic Field During Waking Affects Human Sleep EEG*, 11 NEUROREPORT 3321, 3321 (2000); Reto Huber et al., *Exposure to Pulse-Modulated Radio Frequency Electromagnetic Fields Affects Regional Cerebral Blood Flow*, 21 EUR. J. NEUROSCIENCE 1000, 1000 (2005); Ching-Sui Hung et al., *Mobile Phone 'Talk-Mode' Signal Delays EEG-Determined Sleep Onset*, 421 NEUROSCIENCE LETTERS 82, 82 (2007); *see also Cellphone Radiation Linked to Insomnia, Confusion, Headaches, Depression*, FOX NEWS (Jan. 20, 2008), http://www.foxnews.com/story/0,2933,324140,00.html. *But see* Christian Haarala, *Pulsed and Continuous Wave Mobile Phone Exposure Over Left Versus Right Hemisphere: Effects on Human Cognitive Function*, 28 BIOELECTROMAGNETICS 289, 289 (2007) (failing to find any effect on sleep or other cognitive function from pulsed RF exposure).

135. Roy Luria et al., *Cognitive Effects of Radiation Emitted By Cellular Phones: the Influence of Exposure Side and Time*, 30 BIOELECTROMAGNETICS 198, 198 (2009).

136. Institute of Environmental Health at the Medical University of Vienna (June 2010).

137. Nora D. Volkow et al., *Effects of Cellphone Radiofrequency Signal Exposure on Brain Glucose Metabolism*, 305 JAMA, 808, 808 (2011).

138. Manasvini Krishna & Pratiksha Kulshrestha, *The Toxic Belt: Perspectives on E-Waste Dumping in Developing Nations*, 15 U.C. DAVIS J. INT'L. L. & POL'Y 71, 71 (2008); Nicola J. Templeton, *The Dark Side of Recycling and Reusing Electronics: Is Washington's E-Cycle Program Adequate?*, 7 SEATTLE J. SOC. JUST. 763, 763 (2009).

U.S. Environmental Protection Agency, for example, tested thirty-four cellphones in conditions that simulated conditions inside of a landfill. It found that all of them leached hazardous amounts of lead at levels on average more than seventeen times the federal threshold for hazardous waste.[139]

People in industrialized countries replace their cellphones more often than any other electronic device, obtaining a new cellphone every twenty months on average.[140] Industrialized countries ship much of this waste to third world nations.[141] The largest portion of the world's e-waste that makes it to recycling, as opposed to simply thrown away as garbage, is recycled in or near the Chinese village of Guiyu. This has turned Guiyu into the most polluted place on earth. Guiyu residents have displayed blood levels of lead alone that are dozens of times higher than the maximum safe exposure level set by the U.S. Centers for Disease Control.[142]

Cellphones contain a relatively rare and expensive mineral, Colton, found mainly in the Democratic Republic of the Congo. Obtaining this mineral has wreaked environmental havoc on that country. "Huge swaths of pristine riverbeds were cleared of all vegetation and animal life," in order to mine the mineral.[143] Among the carnage is the gorilla population of that country and therefore of the world. UNEP reports that the number of eastern lowland gorillas in the national parks of the Congo has dropped ninety percent and only three thousand of these gorillas now survive.[144]

D. Morality

Britain's Prince Charles famously opposed genetic engineering because it "takes mankind into realms that belong to God and to God alone."[145] It is unlikely, however, that moral concerns about genetic engineering have

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139. Alex Pasternack, *The Environmental Costs (and Benefits) of Our Cell Phones*, TREEHUGGER (Sept. 3, 2009), http://www.treehugger.com/files/2009/09/cell-phones-changing-the-world-for-good-and-bad-and-how-we-can-use-them.php.

140. DAVIS, *supra* note 8.

141. Templeton, *supra* note 138, at 763; *see* Bryan Schnedeker, E-Waste in the U.S. and Internationally (2011) (unpublished student paper) (on file with author); *see also* Krishna & Kulshrestha, *supra* note 138, at 71.

142. US GOV'T. ACCOUNTABILITY OFFICE, GAO-08-1044, ELECTRONIC WASTE: EPA NEEDS TO BETTER CONTROL HARMFUL US EXPORTS THROUGH STRONGER ENFORCEMENT AND MORE COMPREHENSIVE REGULATION 18 (2008).

143. DAVIS, *supra* note 8, at 240.

144. *Id.*

145. The Prince of Wales, *The Seeds of Disaster*, SPEECHES (June 8, 1998), http://www.princeofwales.gov.uk/media/speeches/article-the-prince-of-wales-titled-the-seeds-of-disaster-the-daily-telegraph.

played a major role in countries' geopolitical decisions on whether and how to regulate bioengineered food.

European nations, for example, defended their strict regulatory regimes governing bioengineered food before the WTO on the basis of health and safety concerns and not on the basis of morality, even though the General Agreement on Tariffs and Trade allows countries to adopt measures "to protect public morals."[146] Similarly, negotiations on the Biosafety Protocol focused on the risks of agricultural biotechnology to the environment and to human health and even to countries' economies.[147] Nations did not seek to ban or to regulate agricultural biotechnology based on moral concerns. If anything, the CBD seems to support biotechnology as it includes articles that seek to transfer biotechnological know-how to developing countries.[148] The concern in the CBD is not that biotechnology is immoral but rather that its benefits will not be shared equitably.

The cellphone has not raised ethical concerns. People do not worry that man, through the cellphone, is marching into realms that belong to God. Cellphones, however, are not without moral hazard. In addition to the pollution and other environmental devastation described above, they have fueled wars in Africa as groups fight to the death over who should control Colton.

E. Theories in the Current Literature

Regulatory Culture. Lynch and Vogel ascribe the difference in the European Union and the United States' approaches to agricultural biotechnology to their disparate regulatory attitudes. They argue that in the 1970s, the United States adopted a more precautionary approach towards regulation and the European Union nations a laxer one. A decade later they switched. The United States came to eschew regulation and the European

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146. General Agreement on Tariffs and Trade art. XX, para. a, Oct. 30, 1947, 61 Stat. A-11, 55 U.N.T.S. 194; *see generally* Robert Howse & Joanna Langille, *Permitting Pluralism: The* Seal Products *Dispute and Why the WTO Should Accept Trade Restrictions Justified by Noninstrumental Moral Values*, 37 YALE J. INT'L L. 367 (2012); Mark Wu, *Free Trade and the Protection of Public Morals: An Analysis of the Newly Emerging Public Morals Clause Doctrine*, 33 YALE J. INT'L L. 215 (2008).

147. *But see* KLEINMAN, *supra* note 6, at 4 (arguing that today *bona fide* moral concerns must be re-characterized as scientific ones, such as risks to the environment or to human health, in a world which places science above all else).

148. *See, e.g.*, Convention on Biological Diversity, *supra* note 29, at arts. 16, 19.

Union to embrace it.[149] Pollack, Shaffer, Echols and others take issue with this explanation. They note that in the 1980's and 1990's the United States frequently adopted a more precautionary approach toward substances such as possible carcinogens, breast implants, as well as towards nuclear energy than did Europe.[150]

The experience of cellphones, a technology contemporaneous with agricultural biotechnology, adds to skepticism that divergent core regulatory proclivities underlie the international controversy over bioengineered food. The European Union is not inherently more cautious of emerging technologies than is the United States.[151] The United States in fact regulated cellphone emissions three years before the European Union did. In addition, developing countries pushed for the strict international regulation of bioengineered goods, while remaining complacent about the potential hazards of cellphones, further undermining a regulatory culture explanation.

Exogenous Shocks, Public Scares and Media Portrayal. Cass Sunstein stresses publicized scares or what one might call exogenous shocks as the major contributor to the over-regulation of a technology.[152] Many, including this author, note that the 1996 European mad cow disease scare that shook European citizens' confidence in their regulators fueled opposition to bioengineered food.[153] However, as the history of the international regulation of biotechnology traced above indicates, the international demand to regulate biotechnology emerged in 1987, nearly a decade before the mad cow disease scare. The international push to strictly regulate agricultural biotechnology, therefore, cannot be explained as primarily flowing from a major public scare.

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149. Diahanna Lynch & David Vogel, *The Regulation of GMOs in Europe and the United States: A Case-Study of Contemporary European Regulatory Politics*, COUNCIL ON FOREIGN RELATIONS (Apr. 5, 2001), http://www.cfr.org/agricultural-policy/regulation-gmos-europe-united-states-case-study-contemporary-european-regulatory-politics/p8688.

150. POLLACK & SHAFFER, *supra* note 42, at 72; SUNSTEIN, *supra* note 2, at 20. *See generally* Jonathan B. Wiener & Michael D. Rogers, *Comparing Precaution in the United States and Europe*, 5 J. RISK RES. 317 (2002).

151. *Accord* SUNSTEIN, *supra* note 2, at 34; Weiner & Rogers, *supra* note 150 (finding that Europe is not inherently more cautious than the United States). For a discussion of the EU perspective see Peter H. Sand, *The Precautionary Principle: a European Perspective*, 6 HUM. & ECOLOGICAL RISK ASSESSMENT 445, 448 (2000).

152. SUNSTEIN, *supra* note 2.

153. *See, e.g.*, POLLACK & SCHAFFER, *supra* note 42, at 75; PEW, *supra* note 47; Robert Paarlberg, *The Global Food Fight*, 79 FOREIGN AFFAIRS 24 (2000); Sabrina Safrin, *Treaties in Collision? The Biosafety Protocol and the World Trade Organization Agreements*, 96 AM. J. INT'L L. 606 (2002).

Moreover, the shaking of consumer confidence in regulators affected cellphones as well as bioengineered food.[154] Adam Burgess explains that Britain's Stewart Report on cellphone risk was "very directly shaped by these 'lessons' of [bovine spongiform encephalopathy (BSE)]." Had there been no BSE scare, "it can confidently be argued that there would have been no inquiry into cellphones."[155]

Closely linked to exogenous shocks is the portrayal of the technology in the popular press. The popular press trumpeted the hazards of both bioengineered food and cellphones. The media ominously warned that cellphones might "fry the brain" and may form "the new tobacco."[156] Highly publicized lawsuits alleged that cellphones caused death by cancer.[157] The British media's "fascination" with the potential harmful health effects of cellphones peaked in 1997–1999.[158] This precisely coincides with the negotiation of the Biosafety Protocol.

Yet, governments and the international community responded to scares about the potential risks of cellphones by commissioning studies rather than by encumbering their availability, as most did with bioengineered food.

Institutional Factors. Pollack and Shaffer suggest that whether a country adopts a strict or a lax regulatory approach to a technology partly turns on which agency within a country bears primary responsibility for regulating it and for representing its country at international negotiations. They surmise that had the EPA—rather than the industry-friendly USDA—taken the lead for regulating biotechnology, the United States would have adopted a stricter more EU-like process-based approach.[159] In the EU as well as in many other countries, environmental ministries assumed the lead in regulating biotechnology, edging out ministries more favorably disposed to the technology.

The cellphone experience gives some support to this regulatory lead theory. Regulation of the cellphone fell either within the remit of favorably inclined communications ministries or at least not within the sole jurisdiction of a hostile or skeptic agency.[160] This multi-agency approach has likely contributed to the fact that emphasis on the benefits of cellphones has

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154. ADAM BURGESS, CELLULAR PHONES, PUBLIC FEARS, AND A CULTURE OF PRECAUTION 225 (2004).

155. *Id.* at 225–26.

156. *Id.* at 1, 3.

157. KLEMENS, *supra* note 13, at 159, 161; BURGESS, *supra* note 154, at 6.

158. BURGESS, *supra* note 154, at 1.

159. POLLACK & SHAFFER, *supra* note 42, at 45–48, 60, 72.

160. *See, e.g.*, *Regulatory Landscape of Latin America*, 14 MOBILE PHONE NEWS, Nov. 4, 1996 (listing telecom regulatory agencies for major Latin American countries).

persistently accompanied consideration of their potential risks at the policy-making level. The 1999 EU Council Recommendation, for example, stressed that member nations take into account the safety benefits of cellphones, such as their usefulness in emergency situations, when taking action to limit exposures.[161] At the international level, the ITU, an international organization favorably disposed to new telecommunications technologies, has actively promoted cellular telecommunications. The choice of domestic and international regulatory lead, however, is not a matter of happenstance. Rather, which agency takes the regulatory helm reflects how national governments and the international community more broadly view the technology from the outset.

Scholars have also pointed to the European Union's highly politicized rule-making system with its numerous veto points as a key factor in Europe's strict restrictions on bioengineered food.[162] Yet, these EU institutional structures existed for cellphone technology as well. Although bioengineered food and the cellphone faced the same EU institutional structure, that structure responded to public fears about the safety of the new technologies by strictly regulating bioengineered food, while leaving cellphone technology largely unencumbered.

Culture. Cultural theorists argue that culture plays a core, if not the most important, role in determining a society's response to risk.[163] Marsha Echols posits that European governments and their constituencies generally have been more receptive to traditional methods of food production, as exemplified by raw milk cheese and cured meats, while cautious about new technologies such as irradiation and biotechnology. Americans take the opposite approach. They harbor greater skepticism of traditional methods and more favorably view new approaches to food preservation and production.[164] According to Echols, these cultural differences explain the different reactions of Europe and the United States to bioengineered food.[165]

Douglas and Wildavsky, in their seminal work on social and cultural risk preference, characterize people as egalitarian (concerned with risk and social inequality), individualistic, or hierarchical (conservative and defend status quo).[166] While culture clearly plays a role in how a society approaches risk, it

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161. Council Recommendation of 1999, *supra* note 57.

162. POLLACK & SHAFFER, *supra* note 42, at 63–64, 72.

163. Dan M Kahan, Paul Slovic, Donald Braman & John Gastil, *Fear of Democracy: A Cultural Evaluation of Sunstein on Risk*, 119 HARV L. REV. 1071, 1084 (2006) (book review).

164. *See* Marsha A. Echols, *Food Safety Regulation in the European Union and the United States: Different Cultures, Different Laws*, 4 COLUM. J. EUR. L. 525, 530–33 (1998).

165. *Id.* at 534.

166. *See* MARY DOUGLAS & AARON WILDAVSKY, RISK AND CULTURE (1983).

appears difficult to characterize countries as a whole as egalitarian, individualistic or hierarchist. The egalitarian and hierarchical Europeans, for example, readily develop, produce and use novel pesticides.[167] They also accepted bioengineered enzymes in food production.[168] When we consider the cellphone, the "individualistic" Americans took action, albeit modest, to regulate cellphones several years before the "egalitarian" Europeans did. Furthermore, as discussed earlier, nearly all countries, regardless of culture, have taken few steps to regulate cellphones.

Divergent Interests. Several scholars, such as Thomas Bernauer, have pointed to divergent interests and interest group pressures between the United States, with strong biotechnology firms, and Europe, with weaker ones, as accounting for the difference in regulatory approach.[169] As developed more fully below, a comparison of agricultural biotechnology with the cellphone supports and builds upon these interest-based, or what might be called political-economic, theories for the agricultural biotechnology controversy.

III. A FRAMEWORK FOR PREDICTING GLOBAL TECHNOLOGY CONFLICTS

The early and universal resistance to substantially regulating cellphones despite their risks to human health and to the environment versus the contemporaneous regulatory encumbrance of agricultural biotechnology flows in key part from two major geopolitical factors. These factors can help predict the international acceptability of other emerging technologies, such as nanotechnology and 3D printing.

A. Big Tent v. Small Tent Technologies

Nations and their corporations like to view themselves as technology leaders. But technological overarching dominance or exclusivity, while good for corporate profits, stock prices and national pride, is antithetical to global comity. Technologies with a global tent of stakeholders will more readily be accepted internationally than those with a small tent of international

167. Gregory D. Graff & David Zilberman, *Explaining Europe's Resistance to Agricultural Biotechnology*, 7 AGRIC. AND RESOURCE ECON. UPDATE 1 (2004).

168. *See* discussion *infra* p. 48.

169. Thomas Bernauer, in particular, points to divergent interests and interest group pressures between the United States, with strong biotechnology firms, and Europe, with weaker ones, as accounting for the difference in regulatory approach. THOMAS BERNAUER, GENES, TRADE AND REGULATION: THE SEEDS OF CONFLICT IN FOOD BIOTECHNOLOGY (Princeton University Press 2003); Thomas Bernauer & Erika Meins, *Technological Revolution Meets Policy and the Market: Explaining Cross-National Differences in Agricultural Biotechnology Regulation*, 42 EUR. J. POL. RES. 5, 643 (2003); *see also* Graff, Hochman & Zilberman, *Political Economy*, *infra* note 186.

stakeholders. This holds true regardless of a technology's actual or potential threat and irrespective of the technology's portrayal in the popular press or a nation's regulatory culture.

From an international perspective, agricultural biotechnology represents a small tent technology. Rather than multiple countries developing and bringing on board the technology in concert, one country—the United States—dominated. In contrast, the cellphone constituted a big tent technology. From the outset, many countries had a stake in it.

While the first cellphone call was placed in the United States, Japan conducted the first cellphone system experiment in 1975.[170] It further established the world's first commercially available cellular phone system in Tokyo at the end of 1979.[171] Meanwhile, Finland took the lead in Europe. It established a cellular phone system in 1982, which the other Nordic countries soon joined.[172] Chicago residents enjoyed the first American commercial cellular service in 1983. Cellular phone service began in Great Britain and in France in 1985, in West Germany in 1986 and in East Germany in 1990.[173] Cellphones also penetrated Africa, with 7.5 million cellphones on the continent in 1994 and an average annual increase of cellphone penetration over the next ten years of 58%, a higher rate of increase than even Asia's 34%.[174] In addition, non-U.S. corporations, such as Vodaphone, took the lead in spreading cellphones to new countries.

The small tent nature of biotechnology versus the big tent nature of the cellphone manifests itself first and most importantly in the innovative space, then in the marketplace, and finally in the realm of economic benefit sharing.

1. Innovation

Graff and Zilberman reveal that in the foundational decades of agricultural biotechnology, 1982–2002, North American inventors received 3,035 U.S. patents covering "agbiotechnologies and crop genetics," while European inventors received only 774 patents.[175] My analysis of the U.S. Patent and Trademark Office ("PTO") databases reveals that between 1982–1992, U.S.

170. KLEMENS, *supra* note 13, at 49.
171. *Id.* at 65–66.
172. *Id.* at 66.
173. *Id.* at 67.
174. *Id.* at 131.
175. Graff & Zilberman, *supra* note 167, at 3. While Graff and Zilberman track U.S. patents, given the size of the U.S. market, we would expect European inventors to file agbiotech patents in the U.S. and not only in their European home states.

inventors received 79% of patents in the class most relevant to agricultural biotechnology (technology class 800): 129 compared to 34 issued to foreign inventors.[176] Between 1993–2003, they received 75% of such patents: 2821 compared to 944 issued to foreign inventors.[177] Overall, between 1963–2011, U.S. inventors received three times as many patents in the class most relevant to agricultural biotechnology than their foreign counterparts: 7515 patents compared to 2443 patents.[178]

In contrast, patent ownership and innovation in telecommunications as well as in digital communications, the two patent classes covering cellular communications, displayed global diversity. In sharp contrast to agricultural biotechnology, where U.S. inventors have received approximately 75% of U.S. patents issued, foreign inventors have received about as many U.S. patents in the fields of digital or pulse communications and telecommunications as their U.S. counterparts.[179] Between 1982–1992, in the digital or pulse communications field, the U.S. patent office granted U.S. inventors 1681 patents and foreign inventors 1593 patents. In the telecommunications field, it granted U.S. inventors 1314 patents and foreign inventors 1024 patents.[180] Thus, roughly speaking, in the foundational decade for cellphone communications, U.S. inventors received 51% and foreign inventors received 49% of U.S. patents for digital or pulse communications and 56% and 44% respectively of U.S. telecommunications patents.[181] In the next decade, 1993–2003, U.S. inventors received 51% (6027 patents) and foreign inventors received 49% (5,748) of U.S. patents in the field of digital or pulse communications.[182] U.S. inventors received 52% (6,659 patents) and foreign inventors received 48% (6,177 patents) of U.S. telecommunications patents.[183]

Overall, between 1963 and 2011, foreign inventors received almost as many U.S. patents as did U.S. inventors in the fields key to cellphone

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176. Patent Technology Monitoring Team, *Extended Year Set: Patenting by Geographic Region (State and Country), Breakout by Technology Class, Count of 1963–2011 Utility Patent Grants*, U.S. PATENT AND TRADEMARK OFFICE, www.uspto.gov/web/offices/ac/ido/oeip/taf/stcteca/regions_stcl_gd.htm (last modified Mar. 26, 2014, 4:17 PM).

177. *Id.*

178. *Id.*

179. *Id.*

180. *Id.*; PATENTING BY GEOGRAPHIC REGION BREAKOUT BY TECHNOLOGY CLASS COUNT OF 1963–2011 UTILITY PATENT GRANTS, *available at* www.uspto.gov/web/offices/ac/ido/oeip/faf/clsstca/usastccl_gd.htm (last visited Sept. 24, 2014).

181. *Id.*

182. *Id.*

183. *Id.*

communications.[184] The U.S. patent office granted U.S. inventors 24,128 and foreign inventors 22,696 telecommunications patents: 51.5% to 48.5%. U.S. inventors received 18,103 digital communications patents compared to 17,222 received by foreign inventors: 51% to 49%.[185]

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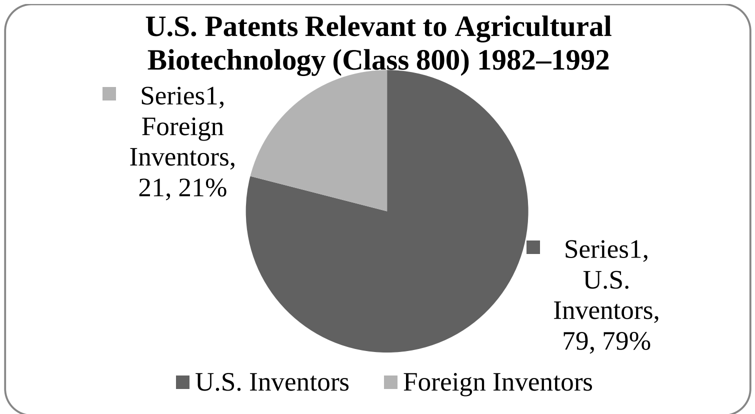
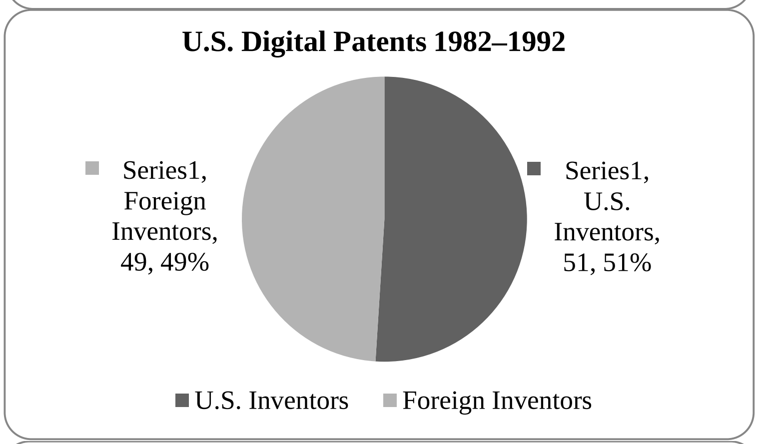
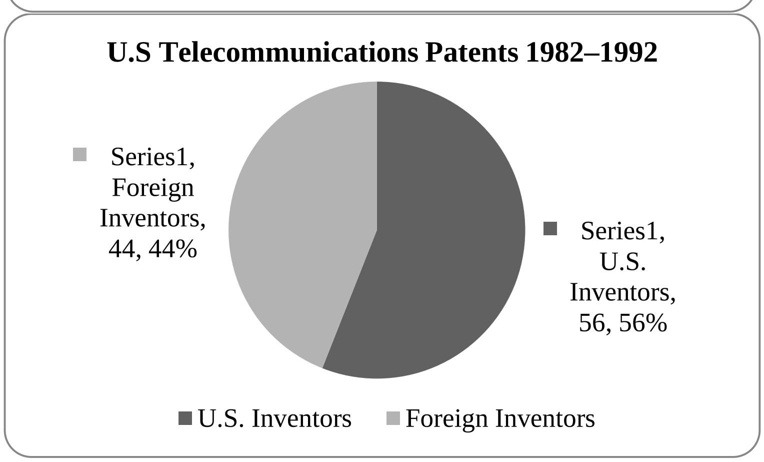
184. *Id.*
185. *Id.*

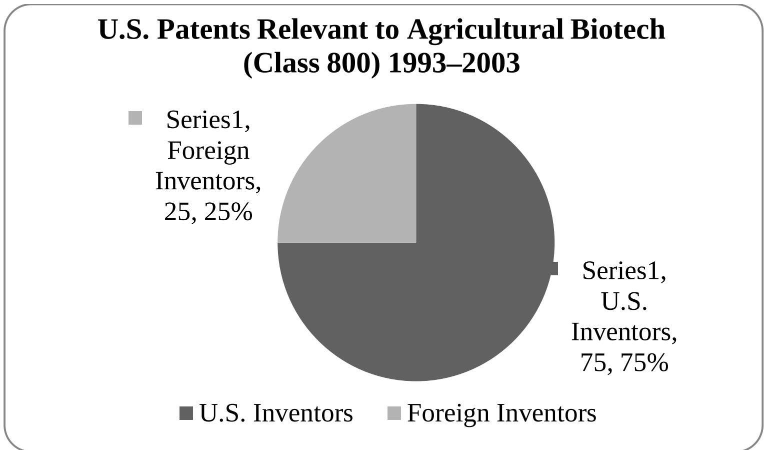
U.S. PATENTS 1982–1992

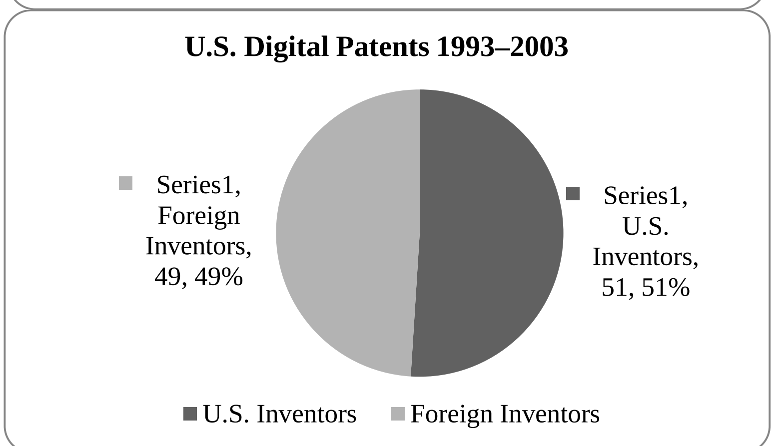


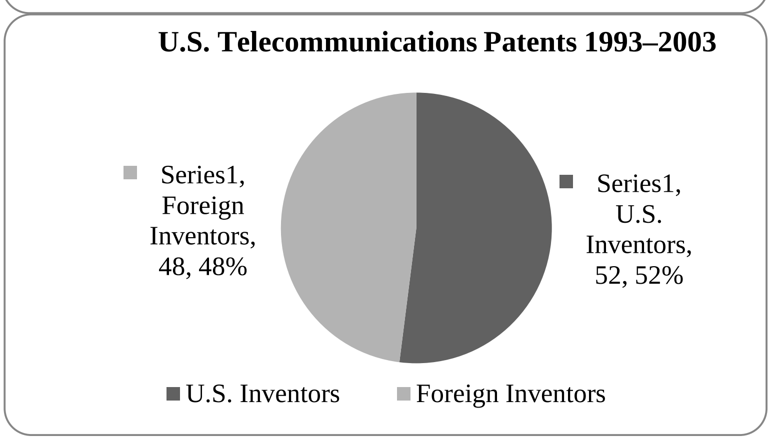




U.S. PATENTS 1993–2003







Furthermore, agricultural biotechnology patents granted to United States' inventors manifest greater value or quality than those granted to their foreign counterparts. In other words, not only were U.S. inventors receiving 75% to 80% of patents relevant to agricultural biotechnology, they were also receiving the most important ones. Scholars track the number of citations that a patent receives from other patents as one way to test a patent's value.[186] Since 1980, agbiotech patents granted to U.S. inventors have on the whole received ten times more patent citations than those granted to European inventors.[187] Graff and Zilberman find this difference particularly pronounced during the 1980s and early 1990s, the foundational years of the technology and before there existed much public awareness of, let alone opposition, to it.[188] We cannot, therefore, explain the difference in innovative capacity as primarily due to a flight of agricultural biotechnology research and development from a hostile Europe, though this flight did eventually occur.[189]

In contrast, patents owned by foreign corporations relevant to cellphone technology have manifested comparable value or quality as those owned by U.S. corporations. For example, a 2004 survey examined the ownership of the 7796 patents important for third generation cellphone technology.[190] Of the 265 patents determined by the survey authors to be most essential, Finnish Nokia owned 54 (20%), Swedish Ericsson owned 37 (14%), and U.S. Qualcomm and Motorola together owned 109 (41%), with others owning the rest.[191] Forty-one different companies owned patents key to third generation technology.[192]

The innovative dominance of the United States in agricultural biotechnology versus the global diversity in mobile telecommunications is evident as well when one considers the major patent-obtaining organizations in the fields most pertinent to each technology. According to the U.S. PTO, based on a period spanning 1969–2013, three of the top fifteen organizations obtaining U.S. patents in telecommunications come from the United States (Motorola, Qualcomm, and Broadcom).[193] The remainder hail from Japan, South Korea, Finland, France, Sweden, and Canada.[194] While not in the top

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186. Gregory D. Graff, Gal Hochman & David Zilberman, *The Political Economy of Agricultural Biotechnology Policies*, 12 AGBIOFORUM 34, 39 (2009).

187. *Id.*

188. *Id.* at 40.

189. *Id.*

190. David J. Goodman & Robert A. Myers, *3G Cellular Standards and Patents*, IEEE WIRELESSCOM 2005 (June 13, 2005), http://eeweb.poly.edu/dgoodman/wirelesscom2005.pdf.

191. *Id.*

192. *Id.*

193. *See Extended Year Set—Patenting in Technology Classes, Breakout by Organization*, U.S. PATENT & TRADEMARK OFFICE (last modified Mar. 26, 2014, 9:17 AM), http://www.uspto.gov/web/offices/ac/ido/oeip/taf/tecasga/455_torg.htm.

194. *Id.*

fifteen, Germany's Siemens is a major telecommunications patent-obtaining entity as well.[195] Moreover, patent ownership spreads among these countries rather than concentrating in a single country or company. Of the top fifteen patent-obtaining organizations, taken together, U.S. companies on this list received 6107 patents, European companies received 6126 patents, Japanese companies received 5234 patents, South Korean companies received 3392 patents, and the top Canadian company received 1137 patents.[196]

In the technology class most pertinent to agricultural biotechnology, in contrast, twelve of the top fifteen patent-obtaining organizations from the United States, based again on a period spanning 1969–2013.[197] Not only do Pioneer Hi-Bred and Monsanto hold the top two spots, they dwarf the other companies.[198] Together they own more U.S. patents (4460) than the other thirteen organizations combined (2566) and certainly more than the non-U.S. organizations, which together have obtained only 650 U.S. patents in this same period.[199] We see no geographic parity. U.S. organizations, which together have obtained 6376 patents, overwhelm the sole E.U. company on the list, German BASF Plant Science (146 patents), and the two Swiss companies Syngenta and Mertec (504 patents combined).[200]

Finally, not only does cellular telecommunications technology reflect global innovative diversity, it also forms certain influential countries' most important innovative fields. According to the World Intellectual Property Organization, nearly half of all of the Patent Cooperation Treaty applications originating from China published in 2010 belonged to the digital communications and telecommunications fields.[201] More than a third of Sweden's PCT applications came from these fields as did more than a quarter of Korea's PCT applications.[202] Telecommunications and digital communications fields are technological areas that these countries, as well as

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195. *See id.*

196. *See id.* Patents obtained by Nokia Mobile Phones LTD and Nokia Telecommunications OYJ were included with patents obtained by Nokia Corporation.

197. U.S. PATENT & TRADEMARK OFFICE, EXTENDED YEAR SET—PATENTING IN TECHNOLOGY CLASSES, BREAKOUT BY ORGANIZATION 1969–2013 UTILITY PATENT GRANTS BY CALENDAR YEAR OF GRANT WITH PATENT COUNTS BASED ON PRIMARY PATENT CLASSIFICATION, TECHNOLOGY CLASS 800 (2014), *available at* http://www.uspto.gov/web/offices/ac/ido/oeip/taf/tecasga/800_torg.htm.

198. *See id.*

199. *Id.* Patents owned by Monsanto Company, Inc. and Monsanto Corporation were included in the total number of patents attributed to Monsanto.

200. *Id.*

201. WORLD INTELL. PROP. ORG., PCT THE INTERNATIONAL PATENT SYSTEM YEARLY REVIEW 25 (2010).

202. *Id.*

Japan and Finland, simply cannot afford to lose and therefore would not want to constrain.[203]

2. The Marketplace

The dominance of the United States in agricultural biotechnology manifests itself not only in the innovative space but also in the marketplace. At the time of the negotiation of the Biosafety Protocol, 72% of GMO crops were grown in the United States.[204] Few countries perceived themselves as having a real stake in the technology as producers.[205] Those that did, primarily Argentina and Canada, who together produced 27% of the world's GMO crops in 1999,[206] and to a much lesser extent Australia, Chile, and Uruguay, allied themselves with the United States in the negotiation of the Biosafety Protocol.[207] They supported the international regulation of genetically modified organisms intended for release into the environment, but opposed international rules covering GMO commodities intended for food, feed or processing.[208] They also opposed internationally mandated labeling schemes, though Australia less so.

Production of cellphone technology by contrast has consistently displayed considerable global diversity. Major producers of cellphone technology and equipment span both oceans. These include Nokia from Finland, Ericsson from Sweden, Siemens from Germany, Sony from Japan, HTC from Taiwan, Samsung from South Korea, ZTE and Huawei from China, Motorola and Qualcomm from the United States, and Research in Motion from Canada.[209]

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203. *See id.*

204. CLIVE JAMES, GLOBAL REVIEW OF COMMERCIALIZED TRANSGENIC CROPS: 2000, ISAAA BRIEFS NO. 21: PREVIEW at 5 (2000) (listing percentage of global area of transgenic crops by country for 1999).

205. ROBERT L. PAARLBERG, THE POLITICS OF PRECAUTION: GENETICALLY MODIFIED CROPS IN DEVELOPING COUNTRIES 3 (2001) (finding that although regulators approved of the first GM crops and that the crops were "released for commercial use in a half a dozen countries almost simultaneously in 1995–1996," these new crops mainly achieved widespread use in the United States, Argentina, and Canada).

206. JAMES, *supra* note 204.

207. Safrin, *supra* note 153, at 614.

208. *See* Anup Shah, *Biosafety Protocol 1999*, GLOBAL ISSUES, http://www.globalissues.org/article/174/biosafety-protocol-1999 (last updated Mar. 19, 2001) (finding that the above countries "wanted the Biosafety Protocol to only apply to seeds and not commodities.").

209. *See Top Cell Phone Manufacturers*, WORLD-TOP-10.COM, http://www.world-top-10.com/list/Top-Cell-Phone-Manufacturers/49 (last visited Sept. 8, 2014).

Furthermore, as mentioned earlier, application of cellphone technology from its earliest days occurred throughout the world.[210]

In addition, significant global collaboration and international joint ventures have characterized cellphone technology from the earliest days of the technology's commercialization. For example, leading cellphone manufacturer Nokia established a key joint venture with U.S. Tandy Corporation to manufacture cellphones in South Korea in 1984 for distribution in the United States through Tandy's RadioShack stores.[211] In the 1990s, cellular communication moved from analog systems to digital ones. U.S. Qualcomm Corporation took the lead in developing code division multiple access ("CDMA") based cellular phone systems.[212] At the same time, South Korea sought to increase its cellular telecommunications presence. It did so largely though a 1991 joint development deal between Qualcomm and the Electronics and Telecommunications Research Institute ("ETRI"), a Korean industrial association.[213] Korea would serve as Qualcomm's first proving ground for a countrywide CDMA system.[214] In return, Qualcomm would donate 20% of its Korean royalties to ETRI.[215] Today, Korea's ETRI is itself a major patent-obtaining entity.

One is hard-pressed to find a comparable example of major and mutually-beneficial transnational industrial collaboration in agricultural biotechnology, particularly in its formative period. Monsanto has formed a joint venture with India's largest seed company, MAHYCO, to produce GMO cotton in India. This joint venture did not take place until 1998, occurred only after Monsanto had first acquired 26% of the Indian seed giant itself, and seemed designed primarily to enable Monsanto to enter the Indian market.[216]

If anything, much of the international agricultural biotechnology story involves less developed and developing countries, including emerging

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210. *See supra* notes 170–74 and accompanying text.

211. STEINBOCK, *supra* note 76, at 101.

212. *Id.* at 216.

213. KLEMENS, *supra* note 13, at 119.

214. According to Guy Klemens, a CDMA system was a first for South Korea. *Id.*

215. *Id.*

216. Bharat Ramaswami & Carl E. Pray, *India: Confronting the Challenge—the Potential of Genetically Modified Crops for the* Poor, *in* THE GENE REVOLUTION: GM CROPS AND UNEQUAL DEVELOPMENT 156, 161 (Sakiko Fukuda-Parr ed., 2007; GREENPEACE, COMPANIES BOUGHT BY MONSANTO (1995–2005) 1 (Christoph Then, ed., 2005), *available at* www.greenpeace.de/sites/www.greenpeace.de/files/greenpeace_ge_companies_bought_by_monsanto_eng_1.pdf; *The Technologist*, BIOSPECTRUM (June 14, 2007), http://www.biospectrumindia.com/biospecindia/news/156728/the-technologist (describing Mahyco Monsanto Biotech).

powerhouses such as Brazil and India, seeking a place for themselves as contributors to and beneficiaries of the technology in a capacity other than simply as passive purchasers or consumers of it. Developing countries, for example, insisted that the Convention on Biological Diversity provide for access to and transfer of technology, particularly of biotechnology.[217] The Convention essentially requires countries to provide or facilitate access to certain biotechnology "under fair and most favourable terms." It also requires them to take measures "with the aim that the private sector facilitates access to, joint development and transfer of [such] technology . . . for the benefit of both governmental institutions and the private sector of developing countries . . . ."[218] While the treaty text reflects developing countries' desire for collaboration, we see few joint development agricultural biotechnology projects on the ground and certainly not during the 1980s and 1990s.

3. Benefit Sharing

Cellphone's big tent versus agricultural biotechnology's small tent appears not only in the innovative space and the marketplace but also in the realm of benefit sharing. Governments and the nations that they represent have been able to share in the benefits of cellphone technology in a way that has eluded them in agricultural biotechnology. They have captured a share of the cellphone market profits through the sale of spectrum rights and have thus joined corporations as direct stakeholders in the emergent technology.

The right of governments to control access to spectrum, the electromagnetic frequencies that carry our cellular and other wireless communications, dates back to the early days of radio communications.[219] It was thus firmly in place at the birth of cellphone technology.[220] In the aftermath of the 1912 Titanic disaster, which many attributed to radio signal interference, governments around the world assumed responsibility for defining and distributing access rights to what U.S. law calls the "public spectrum resource."[221] Ellen Goodman relates that because of signal interference, the law early on came to treat spectrum as a quasi-physical substance to which the government must limit access, just as it limits access

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217. Koester, *supra* note 27, at 180.

218. Convention on Biological Diversity, *supra* note 29, at arts. 16(1), 16(2), 16(4).

219. Ellen P. Goodman, *Spectrum Rights in the Telecosm to Come*, 41 SAN DIEGO L. REV. 269, 278–80 (2004).

220. *See id.*

221. *Id.* at 280–81 (internal quotation marks omitted).

to public forests.[222] In the United States, for example, since 1927 a federal government agency has allocated spectrum for various uses.[223] It issues access licenses to various providers such as radio stations, TV broadcasting networks, or cellphone carriers.[224] This type of regulatory system appears fairly common throughout the world. Most countries have a communications ministry or agency that regulates telecommunications, including cellular telecommunications, and allocates access to radio spectrum.[225]

Radio spectrum, in the words of UK Minister for Small Firms, Trade and Industry is the "raw material" for cellphone communications.[226] Although governments controlled access to the radio spectrum resource, it was not until 1990 that they began to charge for such access.[227] They did so generally through the conduct of wireless license auctions.[228] The first country to conduct a wireless license auction was New Zealand in 1990, followed by India in 1991.[229] The United States' first auction in 1994 netted $617 million for the U.S. treasury.[230] An auction conducted a year later generated an astounding $7.7 billion.[231]

A barrage of auctions soon followed as governments realized the enormous sums that they could make from spectrum access sales.[232] Between 1995–2001, twenty-seven different countries, both in the developed and the

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222. *Id.* at 280.

223. *Id.* at 282 (citing Radio Act of 1927, Pub. L. No. 69-632, 44 Stat. 1162 (repealed 1934)).

224. Thomas Hazlett explains that under this system, no party, including the government, actually owns spectrum. Rather, the people hold the spectrum resource in common. The federal government regulates access to this commonly held resource on behalf of the public. Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's "Big Joke": An Essay on Airwave Allocation Policy*, 14 HARV. J.L. & TECH. 335, 372 (2001).

225. These include, for example, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Chile, Columbia, Denmark, Greece, Guatemala, Hungary, Italy, Mexico, the Netherlands, Nigeria, Panama, Peru, Switzerland, the United Kingdom, and Venezuela. *See, e.g.*, Thomas W. Hazlett, *Property Rights and Wireless License Values*, 51 J.L. & ECON. 563, 590 tbl.C1 (2008); *Regulatory Landscape of Latin America*, 14 MOBILE PHONE NEWS, Nov. 4, 1996.

226. Press Release, Radiocommunications Agency, New Legislation on the Right Wavelength for Business, Consumers, Jobs (Mar. 18, 1998) (quoting Minister for Small Firms, Trade and Industry Barbara Roche), *available at* http://www.ofcom.org.uk/static/archive/ra/publication/press/pre1999/18mar98.htm.

227. *See* Hazlett, *supra* note 225, at 567.

228. *Id.* at 567–78.

229. *Id.*

230. Thomas W. Hazlett, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?*, 41 J.L. & ECON. 529, 535 (1998).

231. Richard E. Wiley, *1995: A Regulatory Review*, 30 TELECOMM. 17, 59 (1996).

232. *See* Ruth Milkman, *Will U.S. Auction Trends Become a Global Auction Nightmare?*, 19 SATELLITE NEWS 6, 6 (1996).

developing world, conducted at least forty-two wireless telephone license auctions for second generation (2G) and third generation (3G) cellular communications, netting billions of dollars for their governments.[233] 3G auctions in Europe generated some $100 billion for European treasuries, with Germany alone obtaining $45 billion.[234] Brazil captured $7.75 billon through the sale of ten cellular licenses in 1997.[235] Cellular phone license auctions in Mexico and Turkey in 1998 netted over $1 billion for Mexico and over $500 million for Turkey.[236]

Governments had thus become shareholders in cellular phone technology. They had every interest in seeing the technology blossom and little interest in curtailing it. A 1996 letter by the President of the Cellular Telecommunications Industry Association, Tom Wheeler, to President Bill Clinton is telling. Wheeler complains that U.S. federal agencies have failed to facilitate the siting of cellular phone antennae on federal lands as President Clinton had directed fifteen months earlier. Believing that his concerns are sure "to capture the President's attention," Wheeler stresses that objections to sitings by such agencies as the National Parks Service, the U.S. Forest Service, the Bureau of Land Management and the Department of Defense have "materially harmed wireless carriers—*especially those who recently paid over $20 billion to the Treasury in the federal spectrum auction*."[237]

The legal status of genetic material—the raw inputs for agricultural biotechnology—and the role of governments to control access to it have proved slippery. Traditionally, unimproved genetic material, particularly plant germplasm, had been viewed as part of the common heritage of mankind.[238] "As part of a global commons, genetic resources were available

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233. The countries conducting these auctions span Western and Eastern Europe, North America, Africa, Latin America and the Caribbean. They include Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Bulgaria, Canada, Czech Republic, Denmark, El Salvador, Germany, Greece, Guatemala, Hungary, Italy, Jamaica, Mexico, Morocco, the Netherlands, New Zealand, Nigeria, Panama, Peru, Switzerland, the United Kingdom and the United States.

234. Dan Briody, *European Telecoms are Getting Desperate*, RED HERRING, Sept. 1, 2001, at 86; Paul Quigley, *Auction Fallout Radiates Far and Wide*, 6 WIRELESS WEEK, Aug. 28, 2000, at 10.

235. JACK W. PLUNKETT, PLUNKETT'S TELECOMMUNICATIONS INDUSTRY ALMANAC 3, 13 (2000).

236. Raymond Cairo, *Telecom Prosperity is Distant Dream, But Turkey Keeps Trying*, BROADBAND NETWORKING NEWS, Sept. 26, 2000; *Lure of Cross-Border Traffic Boosts CDMA to Victory in Mexican PCS Auctions*, PCS WEEK, May 20, 1998.

237. *CTIA Says Antenna Siting is Too Difficult*, WASHINGTON TELECOM NEWS (Dec. 9, 1996) (emphasis added).

238. Cary Fowler, *Protecting Farmer Innovation: The Convention on Biological Diversity and the Question of Origin*, 41 JURIMETRICS J. 477, 478, 487 (2001); *see* John R. Adair, *The Bioprospecting Question: Should the United States Charge Biotechnology Companies for the*

in principle for the use of all (often referred to as open access)."[239] "As such, like information in the public domain, they were a freely accessible good."[240] "Most important[ly], as part of a global commons, genetic resources, like the living resources of the high seas, were not subject to the sovereignty of or appropriation by any State."[241]

"In practice, the global genetic commons allowed researchers to [freely] collect samples of genetic material, with two exceptions."[242] "The open system did not grant [them a] right to trespass [upon] private or state property to obtain genetic samples."[243] "Researchers had to obtain any consent normally required before entering such property."[244] "Also, researchers would pay collectors of such material for [their collection services]."[245] But they had no obligation to obtain national government approval for sampling activities or to compensate the source country where the material was found.[246]

In the early 1990's, developing countries sought to change this and to assert sovereign rights over genetic material.[247] Developing countries harbor most of the world's genetic diversity because they comprise most of the nations that hug the equatorial line where the greatest number of different life forms concentrate.[248] At the end of 1991, developing countries secured an

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Commercial Use of Public Wild Genetic Resources?, 24 ECOLOGY L.Q. 131, 141 (1997) (citation omitted); Kal Raustiala & David G. Victor, *The Regime Complex for Plant Genetic Resources*, 58 INT'L ORG. 277, 278 (2004); Edgar J. Asebey & Jill D. Kempenaar, *Biodiversity Prospecting: Fulfilling the Mandate of the Biodiversity Convention*, 28 VAND. J. TRANSNAT'L L. 703, 707 (1995); International Undertaking on Plant Genetic Resources for Food and Agriculture, Nov. 23, 1983, at art.1, *available at* www.fao.org/Ag/cgrfa/iu.htm.

239. Sabrina Safrin, *Hyperownership in a Time of Biotechnological Promise: The International Conflict to Control the Building Blocks of Life*, 98 AM. SOC'Y J. INT'L L. 641, 644 (2004) (citation omitted); *see also* PATRICIA W. BIRNIE & ALAN E. BOYLE, INTERNATIONAL LAW & THE ENVIRONMENT 141 (2d ed. 2002).

240. Safrin, *supra* note 239, at 644 (citations omitted); *see also* BIRNIE & BOYLE, *supra* note 239.

241. Safrin, *supra* note 239, at 644–45 (citations omitted); *see also* BIRNIE & BOYLE, *supra* note 239.

242. Safrin, *supra* note 239, at 645.

243. *Id.*

244. *Id.*

245. *Id.*; *see also* Asebey & Kempenaar, *supra* note 238, at 718.

246. Safrin, *supra* note 239, at 645.

247. *Id.* at 649–52.

248. *See* LILY LA TORRE LOPEZ, ALL WE WANT IS TO LIVE IN PEACE 208 (1999) (the tropical and subtropical regions of developing countries house ninety percent of the world's biological diversity); *The Complex Realities of Sharing Genetic Assets*, 392 NATURE 525 (1998); *When Rhetoric Hits Reality in Debate on Bioprospecting*, 392 NATURE 535 (1998); Porzecanski et al., *Access to Genetic Resources: An Evaluation of the Development and Implementation of Recent*

Annex to the International Undertaking on Plant Genetic Resources, asserting "sovereign rights over their plant genetic resources."[249] They successfully pressed this point further in the CBD. The CBD recognizes that "the authority to determine access to genetic resources rests with the national governments and is subject to national legislation."[250] It further specifies that access to genetic resources shall be obtained only with the "prior informed consent of the Contracting Party providing such resources," unless that country provides otherwise.[251] As a result, international work to implement the CBD includes model legislation prescribing sovereign ownership or extensive control over genetic resources.[252] In addition, on October 29, 2010, Parties to the CBD adopted a Protocol on access and benefit-sharing, which has yet to enter into force.[253]

Despite these developing country textual victories and the passage of a barrage of domestic laws restricting access to unimproved genetic material, governments have been unable to secure compensation for their genetic material.[254] Unlike spectrum, which because of interference pressure is a finite or quasi-finite resource, raw genetic material is plentiful. In fact, the more genetic resources are shared, the more they are preserved, creating, in

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Regulation and Access Agreements 3 (Columbia Univ. Sch. of Inter'l & Pub. Affairs Envtl. Policy Studies, Working Paper No. 4, 1999), *available at* https://www.cbd.int/doc/case-studies/abs/cs-abs-agr-rpt.pdf [hereinafter *Columbia Access Paper*]; *see also* J.M. Spectar, *Patent Necessity: Intellectual Property Dilemmas in the Biotech Domain & Treatment Equity for Developing Countries*, 24 HOUS. J. INT'L. L. 227, 231 (2002); Christopher Hunter, Comment, *Sustainable Bioprospecting: Using Private Contracts and International Legal Principles to Conserve Raw Medicinal Materials*, 25 B.C. ENVTL. AFF. L. REV. 129, 131, 136 (1997) (Developed countries also destroyed much of their genetic diversity when they destroyed natural habitats for factories, homes etc.).

249. Food and Agriculture Organization Res. 3/91, Comm'n on Plant Genetic Res., 1st Sess., November 7–11, 1994, at Annex III (September 1994).

250. Convention on Biological Diversity, *supra* note 29, at art. 15(1).

251. *Id.* at art. 15(7).

252. Raustiala & Victor, *supra* note 238, at 278; *see* LYLE GLOWKA, A GUIDE TO DESIGNING LEGAL FRAMEWORKS TO DETERMINE ACCESS TO GENETIC RESOURCES 23 (1998); Achim Seiler & Graham Dutfield, *Regulating Access and Benefit Sharing: Basic Issues, Legal Instruments, Policy Proposals*, DAS BUNDESAMT FÜR NATURSCHUTZ 69 (2001), https://www.bfn.de/fileadmin/MDB/documents/access.pdf.

253. Nagoya Protocol to the United Nations Convention on Biological Diversity, *adopted on* Oct. 29, 2010. As of August 22, 2014, fifty-one countries have ratified the Protocol and ninety-two have signed it. *See Status of Signature, and Ratification, Acceptance, Approval or Accession*, CONVENTION ON BIOLOGICAL DIVERSITY, http://www.cbd.int/abs/nagoya-protocol/signatories/default.shtml (last visited August 22, 2014).

254. *See* Safrin, *supra* note 239, at 649–52 (over forty countries have passed laws restricting access to raw genetic material and describing how these laws work).

the words of Carol Rose, "a more the merrier effect."[255] Restricting access to genetic material has proved difficult, and companies and researchers are avoiding genetically rich countries rather than braving the complex and confusing domestic statutes that restrict access to it.[256] At the time of the adoption of the Biosafety Protocol in 2000, developing countries had secured billions of dollars from the sale of cellular licenses for spectrum access with billions more in the offing. In contrast, they had ostensibly received only a million dollars or so worldwide for the sale of access rights to raw genetic material.[257]

Consequence: Restrain v. Enable. We can understand the international push to regulate bioengineered food as a movement by the majority of nations in the world to slow the United States' runaway lead in this technology. Veit Koester of Denmark, one of the three vice-chairmen for the negotiation of the CBD, describes how, while other controversial issues in the negotiation of the CBD reflected tensions and ultimate concessions between developing and developed countries, in the case of biosafety and the need for a prior informed consent procedure for bioengineered organisms, "the confrontation was between the US being against such a system on the one side, and the rest of the world on the other side favouring—at that time at least—that system."[258] The impetus to restrain biotechnology does not flow from a desire to protect domestic industry, as the agricultural biotechnology industry may commonly believe, but rather from a desire for some measure of international balance in an emerging technology.

We can see this aspect of the dynamic in a facet of the Biosafety Protocol that scholars have not focused on: the United States' peculiar exclusion as a non-party. The CBD provides that only a party to the CBD may become a party to its protocols.[259] Thus, even if the United States wanted to join the Protocol, it cannot unless it joins the CBD. The CBD is a separate and operatively unrelated treaty. The heart of the Biosafety Protocol and its greatest contribution to protecting the environment from the risks of biotechnology is its advanced informed agreement procedure. That procedure

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255. Carol M. Rose, Essay, *The Several Futures of Property: Of Cyberspace and Folk Tales, Emission Trades and Ecosystems*, 83 MINN. L. REV. 129, 181–82 (1998).

256. *See* Safrin, *supra* note 239, at 657–58, 669.

257. Merck reportedly paid Costa Rica approximately one million dollars for access rights. KERRY TEN KATE & SARAH A. LAIRD, THE COMMERCIAL USE OF BIODIVERSITY 7 (Book Development and Production eds., 1999). One is hard pressed to find another confirmed report of monetary payment for access rights.

258. Koester, *supra* note 27, at 180. Mr. Koester subsequently chaired the negotiations of the Biosafety Protocol.

259. Convention on Biological Diversity, *supra* note 29, at art. 32(1).

essentially requires exporting countries to notify and provide information to importing countries prior to shipping bioengineered organisms intended for release into the environment so that importing countries can perform a risk assessment.[260] The procedure thus assists countries of import, particularly developing countries, by shifting some of the implementation burden to countries of export. Every time the Protocol says "The Party of Export shall," which it does repeatedly, it engages in international burden sharing or burden shifting. At the time of the negotiation of the Protocol, the United States was the country of export the overwhelming majority of the time.[261]

Yet, no attempt was made during the negotiation to structure the Protocol to enable the United States to join. For example, the Protocol could have been structured as a stand-alone agreement negotiated under the auspices of the CBD or UNEP rather than as a Protocol to the CBD. The CBD provides that the Parties to the Convention shall consider the need for a protocol to govern the trade in bioengineered organisms.[262] It does not mandate a protocol or otherwise dictate the form of any resulting legal instrument.

The European Union, in particular, cut off any consideration of such an option. It eliminated early on final clauses that would have left open the possibility of the agreement being a stand-alone treaty. By keeping the United States out of the Protocol, other countries had a freer hand in designing the Protocol's substantive provisions as well as subsequent rules on labeling and liability and compensation. This point, while important, should not be overstated. The United States participated extensively in the negotiation of the Protocol, had allies, and countries bore in mind the reality of the trade in bioengineered food and did not want the United States actively opposed to the Protocol.[263] However, by keeping the United States both in the room and at arms length, countries could slow bioengineered agriculture.

In contrast to agricultural biotechnology, more nations, in particular European nations, produced and therefore had a stake in bioengineered

260. The exporting country can either provide the notification itself or require exporters subject to its jurisdiction to do so.

261. Not only was the United States the world's largest producer of GMO crops, it was also the world's largest exporter of soybean and corn. *See* JAMES, *supra* note 204; *see generally* *Soybeans and Oil Crops*, U.S. DEP'T. AGRIC., http://www.ers.usda.gov/topics/crops/soybeans-oil-crops/trade.aspx (last visited Oct. 26, 2014); *Corn*, U.S. DEP'T. AGRIC., http://www.ers.usda.gov/topics/crops/corn/trade.aspx (last visited Oct. 26, 2014). Soybean and corn comprised 82% of all GMO crops grown in 1999. JAMES, *supra* note 204, at 8.

262. Convention on Biological Diversity, *supra* note 29, at art. 19(3).

263. Second Ordinary Meeting of the Conference of the Parties to the Convention on Biological Diversity, *supra* note 33, dec. II/5 (authorizing the negotiation of the Biosafety Protocol and expressly providing that all countries, as opposed to only Parties to the Convention on Biological Diversity, could participate in the Protocol's negotiation).

pharmaceuticals. While championing the inclusion of human health in the Protocol, the European Union paradoxically sought to exclude bioengineered pharmaceutical goods, products clearly implicating human health, from the Protocol's ambit.[264] Developing countries who produced neither bioengineered food nor bioengineered drugs wanted the Protocol to cover both. In the end, the Protocol expressly excludes bioengineered pharmaceuticals from its regulatory scope.[265] This represents in key part a concession to the big, or materially bigger, tent of nations with a stake in pharmaceutical biotechnology.

In a similar vein, the European Union expressly exempted genetically-modified food enzymes from its domestic GM approval and labeling requirements. The European Union has one of the largest GM enzyme producing industries in the world. GM enzymes help produce such goods as cheese and beer. Beer, cheese and other foods produced using GM enzymes do not come with labels in Europe, even though other GM-derived foods do.[266]

The contemporaneous meager domestic regulation of cellphones, the absence of regulation internationally, as well as the international collaborative work on standard-setting can be understood as the effort by the international community to facilitate the growth of a technology that many nations had and have a stake in. The future of cellphone technology did not belong to one or two nations, but to all nations. Most nations had skin in the cellphone technology game.

B. Technologies that Embody Nations' Hopes or Fears for Their Future

Sturken and Thomas note that technology serves as a canvas upon which societies project their concerns and aspirations for their future.[267] Societies can perceive a technology as a savior and imbue it with overly optimistic visions for the future. Conversely, depending on a society's fears, the technology can trigger anxiously dystopian visions of the future. This sociological insight helps us understand the disparate international receptions to the cellphone and to agricultural biotechnology. The cellphone served as

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264. Sabrina Safrin, *The Un-Exceptionalism of U.S. Exceptionalism*, 41 VAND. J. TRANSNAT'L L. 1307, 1332–33 (2008).

265. Cartagena Protocol on Biosafety to the Convention on Biological Diversity, *supra* note 36, at art. 5.

266. POLLACK & SHAFFER, *supra* note 42, at 71.

267. TECHNOLOGICAL VISIONS: THE HOPES AND FEARS THAT SHAPE NEW TECHNOLOGIES 3 (Marita Sturken, Douglas Thomas, & Sandra J. Ball-Rokeach eds., 2004).

the technological embodiment of many nations' aspirations for their future. Agricultural biotechnology in contrast represented the technological embodiment of their fears.

The cellphone comes of age at a time of greater European unification, integration and growth. During the late 1980s and 1990s, the European Union begins its rapid expansion from twelve members in 1989 to twenty-five members by 2004. Throughout the 1990s, the European Union and its institutions dramatically grow and strengthen. The Maastricht Treaty, with its goal of creating an economic and monetary union by 1999, concludes in 1992 and enters into force in 1993. European countries cede increasing sovereign powers to the Union through the conclusion of the 1997 Treaty of Amsterdam and the 2001 Treaty of Nice. The Euro launches in January of 1999. The citizens of this expanded and increasingly integrated European Union move from European nation to European nation in greater numbers and with greater frequency. People come to view themselves not only as citizens of their particular country but also as citizens of a united Europe.

The cellphone meshes perfectly with the ideal of European unification. The cellphone connects people. It knits nations together. The pursuit of a single mobile telecom standard for Europe, such that cellphones can easily work between European countries, becomes an early and paramount goal of the European Union. The European Union pursues a unified standard with tremendous tenacity and with uncharacteristically minimal bureaucracy.

Representatives from eleven European countries met in Stockholm as early as 1982 to plan a European-wide digital cellphone system: the Group Special Mobile (GSM) standard.[268] The European Commission and the European Council provided early and crucial support for the GSM.[269] The European Commission strategy paper backed GSM in May of 1984. The European Council issued a strong endorsement of GSM in 1986. In a decision key to encouraging operators and manufactures to invest heavily in GSM-related R&D, the Council bound European nations to reserve frequencies for GSM in 1987.[270]

European Union institutions threw their weight behind GSM because they found GSM's "pan-European nature and hi-tech features . . . most attractive

268. Jon Agar, *Constant Touch: A Global History of the Mobile Phone*, UNIVERSITY COLLEGE LONDON (July 20, 2010, 11:05 AM), http://www.ucl.ac.uk/sts/staff/agar/documents/agar_constanttouch.

269. Jacques Pelkmans, *The GSM Standard: Explaining a Success Story*, 8 J. EUR. PUB. POL'Y. 432, 444–47 (2001) (detailing numerous European Council and European Commission directives, papers and resolutions promoting and facilitating GSM).

270. *Id.* at 447 (referring to European Council Directive 87/372).

for European integration."[271] In addition, they believed GSM demonstrated "beyond any doubt that the internal [European] market" was "an effective way to boost competitiveness and performance, with economic benefits in lower costs and innovative services."[272] The rise of GSM stands as a stellar example of European Union success.[273]

In sum, European nations want to integrate. They dream of a future with a united Europe. At the apex of this dreaming, a technology appears that embodies and facilitates these dreams. The futuristic technology matches the futuristic aspirations. European nations embrace and facilitate the technology.

The cellphone also matches developing countries' aspirations for their future: a future of economic development and growth and more equal participation in the global economy.[274] Telecommunications services spur economic growth more than most other traditional infrastructure projects.[275] The positive effect of telecommunications services on economic growth is most pronounced in the least developed countries as Anthony Hardy demonstrated in 1980, based on data from forty-five countries.[276]

Cellphones in particular have spurred economic development in poor countries and have played a key role in narrowing the digital divide between the developed and the less developed world.[277] Cellphone technology has allowed developing countries to expand telecommunications services without having to lay and maintain expensive landlines.[278] By bypassing the creation of landline infrastructure, cellphone technology has enabled developing countries to catch up to developed countries in terms of telecom infrastructure.[279] Cellphones cost considerably less than personal computers

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271. *Id.* at 445.

272. *Id.* at 445.

273. STEINBOCK, *supra* note 76, at 108 (describing the pride the EU took in the rise of the GSM standard and in the success of the EU-based cellphone industries, particularly Nokia and Ericsson).

274. *See, e.g.*, Kala Seetharam Sridhar & Varadharajan Sridhar, *Telecommunications Infrastructure and Economic Growth: Evidence from Developing Countries*, 7 APPLIED ECON. & INT'L DEV. 37 (2007).

275. *Id.*

276. Andrew Hardy, *The Role of the Telephone in Economic Development*, 4 TELECOMM. POL'Y 278, 278–86 (1980) (pioneer paper based on data from 45 countries showed that the least developed countries gain the most from telecommunications investment).

277. Raghbendra Jha & Sumit K. Majumdar, *A Matter of Connections: OECD Telecommunications Sector Productivity and the Role of Cellular Technology Diffusion*, 11 INFO. ECON. & POL'Y 243, 268 (1999).

278. *Id.*

279. *Id.*

and do not require literacy to use.[280] Cellphones, therefore, play an even bigger role in closing the digital divide between rich and poor countries than do computers.[281]

Micro-economists have pointed to the dramatic impacts that cellphones have on developing country economies. Robert Jensen found that Indian fishermen who used cellphones to call prospective buyers before they brought their catch to shore increased their profits on average by 8% while decreasing consumer prices by 4%.[282] Aker's studies on grain markets in Niger found that the introduction of mobile phones led to a more efficient grain market that resulted in a 10 to 16% reduction in price dispersion as well as a reduction in waste, yielding welfare gains for producers, traders, and consumers.[283]

Cellphones enable bottom-up economic development by encouraging individual entrepreneurship. They have therefore become the "darling of the microfinance movement."[284] For example, Grameen Phone, Ltd., sponsored by Nobel laureate Muhammad Yunus, has extended microcredit to launch over 250,000 "phone ladies" in Bangladesh.[285]

Macroeconomists have also pointed to the benefits of cellphones on development. In a study on rural South African municipalities, macroeconomists Klonner, Nolen, and Marzolff discovered that "employment increase[d] by 15 percentage points when a locality receive[d] network coverage."[286] Macroeconomists Waverman, Meschi and

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280. *The Real Digital Divide*, ECONOMIST, Mar. 12, 2005, at 11.

281. Sridhar & Sridhar, *supra* note 274, at 39; *id.*

282. Robert Jensen, *The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector*, 122 Q.J. ECON. 879, 883 (2007); *see also* Reuben Abraham, *Mobile Phones and Economic Development: Evidence from the Fishing Industry in India*, 4 INFO. TECH. & INT'L DEV. 5, 12–14 (2007) (discussing how cell phones increase efficiency in the fishing industry).

283. Jenny C. Aker, *Does Digital Divide or Provide? The Impact of Cell Phones on Grain Markets in Niger* 39–40 (Ctr. for Global Development, Working Paper No. 154, 2008); Jenny C. Aker, *Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger*, 2 AMERICAN ECON. J. APPLIED ECON. 46, 57 (2010).

284. Sara Corbett, *Can the Cellphone Help End Global Poverty?*, N.Y. TIMES, Apr. 13, 2008, at MM34, *available at* http://www.nytimes.com/2008/04/13/magazine/13anthropology-t.html?pagewant=all& r=&.

285. *Id.*

286. STEFAN KLONNER & PATRICK NOLEN, CELL PHONES AND RURAL LABOR MARKETS: EVIDENCE FROM SOUTH AFRICA 1 (2010), *available at* http://hdl.handle.net/10419/39968; *see also* Simon Jonas Hadlich, "Mobiles Make the Markets Now": How Mobile Phone Technology Makes Markets in Developing Countries More Efficient 9 (Dec. 5, 2010) (unpublished B.A. essay, University of Amsterdam), *available at* http://www.simoncolumbus.com/wp-content/2011/04/MWilkinson-Research-Essay-Mobiles-Make-the-Markets-Now-SJHadlich.pdf.

Fuss found that cellphones have "a positive and significant impact on economic growth," which "may be twice as large in developing countries compared to developed countries."[287] They further extrapolate that for every additional ten mobile phones per 100 people, a low-income country's Gross Domestic Product rises by an astonishing 0.59%.[288]

If the cellphone embodied nations' aspirations for their future, agricultural biotechnology embodied their fears. The collapse of the Berlin Wall in 1989 left the United States as the world's sole superpower and resulted in general concern of a world dominated by this single superpower. John Jackson notes that a major desire underlying the 1994 Uruguay trade round was to "'reign in' United States unilateralism. This was a fairly explicit goal of the European Community . . . ."[289] The establishment of the world trading system in 1994, however, furthered concern of a world dominated by powerful western corporations, particularly U.S. corporations.[290]

Agricultural biotechnology comes of age precisely at this time. It appears as a technological embodiment of the fear of a world dominated by the capitalist United States. Through genetic engineering, United States corporations appear poised to shape the nature of as well as control the world's food supply—or so people fear. These fears find full expression in the public face of agricultural biotechnology: the aggressive and arrogant Monsanto Corporation.

Begun as a chemical corporation in 1901,[291] Monsanto pursued agricultural biotechnology with greater vigor and resources than any other corporation in the world.[292] By controlling bioengineered genes, it hoped to become the Microsoft of agriculture.[293] It believed that bioengineered genes

287. Leonard Waverman et al., *The Impact of Telecoms on Economic Growth in Developing Countries*, 2 VODAFONE POL'Y PAPER SERIES 10, 11 (2005).

288. *Id.* at 18; *see also* Corbett, *supra* note 284 (discussing the macroeconomic benefits of cell phone ownership); *see also* Sridhar & Sridhar, *supra* note 274, at 91 (finding positive impacts of mobile phones on national output in developing countries when controlling for other factors).

289. John H. Jackson, *International Law Status of WTO Dispute Settlement Reports: Obligation to Comply or Option to "Buy Out"?*, 98 AM. J. INT'L L. 109, 118 n.39 (2004).

290. *See* RICHARD BLACKHURST, REFORMING WTO DECISION MAKING: LESSONS FROM SINGAPORE AND SEATTLE 1 (2000), *available at* http://web.archive.org/web/20070609160303/http://scid.stanford.edu/pdf/credpr63.pdf (discussing resistance at the first Ministerial Conference of the World Trade Organization to the "'inner circle' composed of ministers from 34 of the WTO's 128 members").

291. *Company History*, MONSANTO.COM, http://www.monsanto.com/whoweare/pages/monsanto-history.aspx (last visited Sept. 10, 2014).

292. *See* DANIEL CHARLES, LORDS OF THE HARVEST: BIOTECH, BIG MONEY, AND THE FUTURE OF FOOD 109–10 (Perseus Publ'g ed., 2001) (describing Monsanto's plans to dominate the agricultural market through biotechnology).

293. *Id.*

were to seeds what software was to computers.[294] Under Monsanto's vision, any seed company or farmer wanting to use a Monsanto gene would have to pay a royalty to Monsanto.[295]

Monsanto proceeded to build the world's most vast and valuable arsenal of agricultural biotechnology patents. It owns an early patent on the powerful 35S promoter gene instrumental to agricultural biotechnology.[296] It also holds patents on the most widely used bioengineered crops. Despite bioengineering's potential to provide more nutritious foods and drought resistant crops, approximately 99% of GMO plantings worldwide consist solely of four crops (soybeans, maize, cotton, and canola) involving insect-resistant or herbicide-tolerant traits.[297] Although European companies played an early role in the development of these genetic-engineering traits,[298] American companies pursued these technologies more aggressively. By the second part of the 1990s, Monsanto dominated both of these key GM technologies.[299]

Cary Fowler, John Doyle, Jack Kloppenberg, and Pat Mooney had warned of a day when seed barons would reap monopoly profits from expansions in the law that allowed them to own plants and genes.[300] By the early 1990s, those fears were becoming reality. Not only were corporations owning bioengineered traits and seeds, Monsanto aggressively harnessed these

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294. *Id.*

295. *Id.* at 109–12.

296. *Id.* at 34–35 (describing a promoter as a short strand of DNA that activates the gene to which it attaches). Monsanto's patent filed on April 13, 1984 and granted nearly a decade later covers any man-made genes incorporating the 35S promoter. *Id.*

297. POLLACK & SHAFFER, *supra* note 42, at 302 (citations omitted).

298. *See* Herman Höfte, *Structural and Functional Analysis of a Cloned Delta Endotoxin of Bacillus Thuringiensis Berliner 1715*, 161 EUR. J. BIOCHEMISTRY 273, 273 (1986) (discussing how the Belgium company Plant Genetic Systems first developed genetically engineered plants with insect tolerance by expressing *cry* genes from *B. thuringiensis* in tobacco in 1985); Mark Vaeck et al., *Transgenic Plants Protected from Insect Attack*, 328 NATURE 33, 33 (1987). AgrEvo of Germany acquired PGS in 1996. Swedish Novo Novrodisk and Swiss Novartis also held patents in these areas as did German Hoescht.

299. CHARLES, *supra* note 292, at 46, 69, 73, 120; Barnaby J. Feder, *Monsanto Receives Gene Patent; Files Lawsuit Against 2 Rivals*, N.Y. TIMES, Mar. 21, 1996, http://www.nytimes.com/1996/03/21/business/monsanto-receives-gene-patent-files-lawsuit-against-2-rivals.html.

300. *See* CHARLES, *supra* note 292, at 99, 218–19 (describing Pat Roy Mooney and Hope Shand's establishment of the Rural Advancement Foundation International (RAFI) to combat corporate control over seeds); JACK DOYLE, ALTERED HARVEST: AGRICULTURE, GENETICS, AND THE FATE OF THE WORLD'S FOOD SUPPLY 16–17 (1985) (warning of a "high-tech, house of cards agriculture"); JACK RALPH KLOPPENBURG, JR., FIRST THE SEED: THE POLITICAL ECONOMY OF PLANT BIOTECHNOLOGY 279 (Daniel Lee Kleinman & Jo Handelsman eds., 2d ed. 2004).

patents through their unprecedented licensing agreements.[301] These agreements prohibited farmers from saving seeds from their harvest to replant in subsequent years as farmers had done from time immemorial.[302] Instead, they had to buy new Monsanto seeds every year.[303]

Daniel Charles describes an Ohio seed dealer nailing the new rules on his doorway:

> IMPORTANT INFORMATION FOR INDIVIDUALS SAVING SEED AND REPLANTING . . . Seed from Roundup Ready soybeans cannot be replanted. It is protected under U.S. patents 4,535,060; 4,940,835; 5,633,435 and 5,530,196. A grower who asks to have Roundup Ready seed cleaned is putting the seed cleaner and himself at risk.[304]

Any grower caught replanting seed could face nearly $800 for each acre planted with saved-seed as well as legal fees.[305] In April of 2013, the United States Supreme Court determined that Monsanto may enforce its patents against crops grown from saved seed as its patent rights are not exhausted by the sale of the original seed. [306]

Monsanto's aggressiveness did not stop there. Any seed company wanting to use Monsanto's Roundup Ready gene—"and all of them did"—had to agree that at least 90% of any herbicide-tolerant soybeans it sold would be Monsanto's.[307] These agreements locked German company AgrEvo's herbicide-tolerant soybean, Liberty Link, out of nearly all of this market.[308]

Beginning in 1996, Monsanto embarked on an eight billion dollar international buying spree to acquire seed companies so that it would own not only the bioengineered genes but also the seeds and plant germ plasm.[309] It first acquired Asgrow's corn and soybean business, completely preventing German AgrEvo from partnering with that seed company.[310] It then acquired the independent crop breeding company, Holden's Foundation Seeds, giving it control of Holden's valuable genetic stock.[311] In 1998, it purchased DeKalb,

301. CHARLES, *supra* note 292, at 154.
302. *Id.* at 155.
303. *Id.*
304. *Id.* at 185.
305. *Id.*
306. Bowman v. Monsanto Co., 133 S. Ct. 1761, 1764 (2013), *reh'g denied*, 134 S. Ct. 24 (2013).
307. CHARLES, *supra* note 292, at 196.
308. *Id.* at 195.
309. *Id.* at 195–201.
310. *Id.* at 195–96.
311. *Id.* at 197–98, 200.

Delta, Pine Land, Great Britain's Plant Breeding International as well as Cargill's international seed businesses with operations in Asia, Africa, Europe, and Central and South America.[312] These purchases made Monsanto the world's second-largest seed company, surpassed only by Pioneer HiBred. Moreover, as Charles explains, through Holden's Foundation Seeds, Monsanto now "supplied germ plasm to almost half of the North American market in corn."[313] In addition, "[i]t dominated most of the soybean market that it did not own through contracts with seed companies . . . [and] had established a foothold in seed markets around the globe from Brazil to Indonesia."[314]

Much of the outrage over bioengineered food flows from an abhorrence to having food owned and controlled by such a corporation.[315] Greenpeace, the major environmental group opposed to biotechnology, for example, stresses how Monsanto has "aggressively bought up over [fifty] seed companies around the globe. Seeds are the source of all food. Whoever owns the seeds, owns the food. The process of genetic engineering allows companies, such as Monsanto, to claim patent rights over seeds. Ninety percent of all GE seeds planted in the world are patented by Monsanto and hence controlled by them."[316] The Karnataka State Farmers Association of India, considering "seed freedom to be the key to the nation," started "a campaign of direct action by farmers against biotechnology, called Operation Cremation Monsanto."[317] The campaign adopted as one of its primary slogans: "Bury the World Trade Organization."[318] Indeed, opposition to agricultural biotechnology has consistently accompanied opposition to the WTO.[319] The technology itself represents a dystopia of world domination by a super-power's corporations through the WTO.

In sum, while the cellphone is the technological manifestation of many countries' dreams for their future, agricultural biotechnology is the technological embodiment of their fears. The global opposition to agricultural biotechnology throughout the 1990s and 2000s may not have been as fierce

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312. *Id.* at 201.

313. *Id.*

314. *Id.*

315. *See, e.g.*, MARIE-MONIQUE ROBIN, THE WORLD ACCORDING TO MONSANTO (2011).

316. *New Movie Damns Monsanto's Deadly Sins*, GREENPEACE (Mar. 7, 2008), http://www.greenpeace.org/international/en/news/features/monsanto_movie080307/; *see also supra* note 216 (Greenpeace list of companies acquired by Monsanto).

317. CHARLES, *supra* note 292, at 272 (quoting its leader, Professor Nanjundaswamy) (internal quotation marks omitted).

318. *Id.*

319. *See id.* at 250 (describing the interruption of a WTO meeting by antiglobalization protesters including genetic engineering opponents).

if the leader in the technology was a country other than the United States, such as Brazil or South Africa. By the same token, if China held world leadership in agricultural biotechnology, this may have triggered greater opposition to the technology in the United States as the technology might have fed U.S. fears of a future dominated by China.

CONCLUSION

As we move further into the twenty-first century, an increasing array of powerful civilian technologies will confront nations and their populations the world-over. These include wider applications of nanotechnology, synthetic biology, 3D printing, and a range of enhancements to and means of altering the human body. How nations react to these technologies will be shaped in key part by whether they have a stake in the technologies. The best short-term business result, one of international technological domination, is at odds with international comity. As seen in the case of agricultural biotechnology, situations where one country possesses overwhelming technological domination, particularly where the technology triggers dystopic visions of the future, will engender resistance, international tension, and create demand to stem the technology's spread through extensive, if not excessive, legal constraints. Therefore, when it comes to powerful emerging technologies, corporations and leading technological nations may find it prudent to work to create big tents rather than small ones. They can do so through transnational joint ventures, geographically diverse research and development projects, and applications of the technology that have potential to economically benefit a wide range of nations and their populations.

International technological comity, as illustrated by the cellphone experience, however, comes with its own risks. Countries may turn a collective blind eye to a technology's risks and under-regulate the technology. Ideally, technological big tents should be matched with regulatory big tents, where governments work together to fashion prophylactic but streamlined regulatory responses that are coupled with joint research into potential harms.