AN AGRICULTURAL LAW JEREMIAD: THE HARVEST IS PAST, THE SUMMER IS ENDED, AND SEED IS NOT SAVED

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INTRODUCTION

The saving of seed exerts a powerful rhetorical grip on American agricultural law and policy. Simply put, farmers want to save seed. Many farmers—and many of their advocates—believe that saving seed is essential to farming. But it is not. Farmers today often buy seed, just as they buy other agricultural inputs. That way lies the path of economic and technological progress. Seed-saving advocates protest that compelling farmers to buy seed every season effectively subjects them to a form of serfdom.[1] So be it. Intellectual property law concerns the progress of science and the useful arts. Collateral economic and social damage, in the form of affronts to the agrarian ego, is of no valid legal concern. The harvest is past, the summer is ended, and seed is not saved.[2]

True to the "rhetorical formula" drawn by Puritan orators from the Hebrew prophets Jeremiah and Isaiah, this Article will deliver a

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1. *See, e.g.*, Robert Schubert, *Farming's New Feudalism*, WORLD WATCH MAG., May–June 2005, at 10, *available at* http://www.worldwatch.org/node/574.

2. *Jeremiah* 8:20 (Revised Standard Version).

jeremiad, "recalling the courage and piety of the founders, lamenting recent and present ills, and crying out for a return to the original conduct and zeal."[3] Part I surveys the law on the uses of seed, from planting for nonreproductive use to reverse-engineering and overt sales of patented seed. The Supreme Court's 2013 decision in *Bowman v. Monsanto Co.*[4] completes a cycle that began with the United States' adoption of the international framework for protecting new plant varieties. In a practical if not legal sense, seed saving has exhausted all avenues of recourse.

Part II places the practice of seed saving within its proper economic context. Seed saving is merely one of many traditional practices that contemporary agriculture has eroded. Seed saving, however, poses a uniquely powerful threat to the suppliers of agricultural inputs and to innovation within agribusiness. It has no place in a framework for agricultural policy based on the progress of science and the useful arts. Part III concludes that the decades-long obsession with seed saving has diverted legal attention from genuine problems arising from the intensive use of biotechnology in contemporary agriculture.

I. AN AGRICULTURALLY LITERATE SURVEY OF THE LAW OF SAVED SEED[5]

A. Seed-Saving Basics: From Bin Run to Brown-Bagging

From the United States' accession in 1970 into the international legal system for protecting new plant varieties through the Supreme Court's 2013 decision in *Bowman*, controversies over seed-saving practices have clogged American agricultural law. These disputes have embroiled all branches of intellectual property law, from the law of trade secrets to patent law and the Plant Variety Protection Act, as well as cognate bodies of law such as antitrust. The connecting theme is as simple as it is consistent: farmers just want to save seed. As a federal court observed in one of many suits against Monsanto, the farmer's "real

3. Emory Elliott, *New England Puritan Literature*, *in* 1 CAMBRIDGE HISTORY OF AMERICAN LITERATURE: 1590–1820, at 169, 257 (Sacvan Bercovitch ed., 1994); *accord id.* ("In current scholarship, the term 'jeremiad' has expanded to include not only sermons but also other texts that rehearse the familiar tropes of the formula such as captivity narratives, letters, covenant renewals, as well as some histories and biographies.").

4. 133 S. Ct. 1761 (2013).

5. Portions of this survey draw upon Jim Chen, *The Parable of the Seeds: Interpreting the Plant Variety Protection Act in Furtherance of Innovation Policy*, 81 NOTRE DAME L. REV. 105 (2005).

complaint seems to be that he should be able to save seed from his harvest, regardless of Monsanto's" claims to intellectual property.[6]

Seed saving has deep roots in agrarian tradition. It also enjoys considerable solicitude in international and domestic law. The International Convention for the Protection of New Varieties of Plants, better known by the acronym UPOV (representing the French name of the organization that administers the Convention, *l'Union Internationale pour la Protection des Obtentions Végétales*), commits its contracting parties to "grant and protect breeders' rights."[7] The United States acceded to UPOV in 1970 and again in 1991.[8] The TRIPS Accord—formally, the Agreement on Trade-Related Aspects of Intellectual Property Rights—later reinforced the United States' commitment to "provide for the protection of plant varieties either by patents or by an effective *sui generis* system."[9] Through the passage of the Plant Variety Protection Act of 1970[10] (PVPA) and the Supreme Court's recognition in *J.E.M. Ag Supply, Inc. v. Pioneer Hi-Bred International, Inc.*[11] that sexually reproduced plants eligible for protection under the PVPA may also qualify for utility patents,[12] the United States has fulfilled its obligations under UPOV and TRIPS twice over.[13]

Over time, the PVPA has faded in economic significance. American seed developers have consistently favored utility patents over plant

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6. *Monsanto Co. v. David*, 516 F.3d 1009, 1014 (Fed. Cir. 2008).

7. International Convention for the Protection of New Varieties of Plants, arts. 1–2, 14, Dec. 2, 1961, (revised Nov. 10, 1972; Oct. 23, 1978; and March 19, 1991) [hereinafter UPOV].

8. *See* S. EXEC. REP. NO. 105-15 (1998); H.R. REP. NO. 103-699, at 8–9 (1994), *reprinted in* 1994 U.S.C.C.A.N. 2423, 2424–25. *See generally* Mark D. Janis & Jay P. Kesan, *U.S. Plant Variety Protection: Sound and Fury . . . ?*, 39 HOUS. L. REV. 727, 742–45 (2002).

9. Agreement on Trade-Related Aspects of Intellectual Property Rights art. 27(3)(b), Apr. 15, 1994, 33 I.L.M. 1125, 1208 (1994), *reprinted in* WORLD TRADE ORGANIZATION, THE RESULTS OF THE URUGUAY ROUND OF MULTILATERAL TRADE NEGOTIATIONS 321, 333 (1995).

10. Pub. L. No. 91-577, 84 Stat. 1542 (1970) (codified as amended in scattered sections of 7 and 28 U.S.C.).

11. 534 U.S. 124 (2001).

12. *See id.* at 132, 145. Since 1930, utility patents on *asexually* reproduced plants (except those propagated by tubers) have been available under the Townsend-Purnell Plant Patent Act, 35 U.S.C. §§ 161–164 (2006). *See generally Imazio Nursery, Inc. v. Dania Greenhouses*, 69 F.3d 1560 (Fed. Cir. 1995); *Yoder Bros., Inc. v. California-Florida Plant Corp.*, 537 F.2d 1347 (5th Cir. 1976), *cert. denied*, 429 U.S. 1094 (1977); Cary Fowler, *The Plant Patent Act of 1930: A Sociological History of Its Creation*, 82 J. PAT. & TRADEMARK OFF. SOC'Y 621 (2000).

13. *Cf.* Joseph Straus, *Bargaining the TRIPS Agreement: The Case for Ongoing Public-Private Initiatives to Facilitate Worldwide Intellectual Property Transactions*, 9 DUKE J. COMP. & INT'L L. 91, 104 (1998) (observing that genetic information in plants is amenable to various forms of proprietary protection).

variety certificates.[14] The PVPA's decline can be traced to UPOV and a parallel development in international agricultural law. UPOV allowed its signatory countries to allow farmers to engage in the traditional practice of saving seed:

> [E]ach Contracting Party may, within reasonable limits and subject to the safeguarding of the legitimate interests of the breeder, restrict the breeder's right in relation to any variety in order to permit farmers to use for propagating purposes, *on their own holdings*, the product of the harvest which they have obtained by planting, *on their own holdings*, the protected variety . . . .[15]

UPOV carefully distinguished this "optional" saved-seed provision from three "compulsory" breeders' rights: "(i) acts done privately and for non-commercial purposes, (ii) acts done for experimental purposes and (iii) acts done for the purpose of breeding other varieties."[16]

Whereas UPOV confined this optional exception to the saving of seed by farmers for use "on their own holdings," the Food and Agriculture Organization (FAO) of the United Nations issued a more aggressive interpretation of "farmers' rights." The FAO's Agreed Interpretation of the International Undertaking on Plant Genetic Resources crafted the "concept of Farmers' Rights" from its belief "that farmers of all regions have" made an "enormous contribution . . . to the conservation and development of plant genetic resources, which constitute the basis of plant production throughout the world."[17] Farmers' rights might be interpreted as supporting a stronger entitlement to save seed, not merely for future replanting, but also for resale to other farmers or perhaps even the development of new varieties. As subsequently codified in the International Treaty on Plant Genetic Resources for Food and Agriculture, the United Nations' view of farmers' rights imposed no

14. *See* CTR. FOR FOOD SAFETY & SAVE OUR SEEDS, SEED GIANTS VS. U.S. FARMERS 15 (2013), *available at* http://www.centerforfoodsafety.org/files/seed-giants_final_04424.pdf; JORGE FERNANDEZ-CORNEJO & MARGRIET CASWELL, THE FIRST DECADE OF GENETICALLY ENGINEERED CROPS IN THE UNITED STATES 2 (2006), *available at* http://www.ers.usda.gov/media/255908/eib11_1_.pdf; Daryl Lim, *Self-Replicating Technologies and the Challenge for the Patent and Antitrust Laws*, 32 CARDOZO ARTS & ENT. L.J. 131, 146–48 (2013).

15. UPOV, *supra* note 7, art. 15(2) (emphases added).

16. *Id.* art. 15(1).

17. F.A.O. Conference Res. 4/89, Rep. of the Conference of FAO, 25th Sess., § 3 (Nov. 29, 1989), *available at* http://www.fao.org/docrep/x5588E/x5588e06.htm#Resolution4.

limit on "any rights that farmers have to save, use, exchange and sell farm-saved seed/propagating material, subject to national law."[18]

This returns the focus to domestic law. Section 113 of the PVPA, even before its amendment in 1994, has always allowed farmers to engage in a "bona fide sale for other than reproductive purposes, made in channels usual for such other purposes."[19] This exemption protects routine farmer-to-market sales of crops intended for use as food, feed, fiber, or fuel.[20]

Section 113 has also permitted farmers "to save seed produced by [them] . . . from seed obtained, or descended from seed obtained, by authority of the owner of the variety for seeding purposes and [to] use such saved seed in the production of a crop."[21] This exemption protects the traditional practice known as "bin run," or the use of seed from one crop to produce subsequent crops.[22] At least with respect to self-pollinated crops such as wheat, soybeans, and cotton—all of which reproduce true-to-type—legal protection of bin run effectively restricts a breeder to a single sale of each variety to each individual grower of a particular crop.[23] The bin run exemption is a robust version of copyright law's "first sale" doctrine[24] and patent law's closely related exhaustion doctrine[25]: the plant breeder gets exactly one chance to sell the information "encoded" in PVPA-certified seed to any individual farmer.

As originally enacted in 1970, the PVPA included a third exemption. Section 113's so-called "brown-bag" exemption allowed "a person, whose primary farming occupation is the growing of crops for sale for other than reproductive purposes, to sell such saved seed to other persons so engaged,

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18. FOOD & AGRIC. ASS'N, INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE 13 (2009), *available at* ftp://ftp.fao.org/docrep/fao/011/i0510e/i0510e.pdf. *See generally* MELISSA D. HO, CONG. RESEARCH SERV., R41091, INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE 13 (2010), *available at* http://www.eoearth.org/files/169001_169100/169086/r41091.pdf; S. EXEC. REP. NO. 111-7 (2010), *available at* http://www.foreign.senate.gov/download/?id=6DAEE400-AA0D-49EB-8858-90777FBBAFC2.

19. 7 U.S.C. § 2543 (2006).

20. *See* Scott D. Wegner, *The Plant Variety Protection Act: Has the Farmer Exemption Swallowed the Act?*, AGRIC. L. UPDATE, Apr. 1992, at 5, *available at* http://nationalaglawcenter.org/wp-content/uploads/assets/aala/04-92.pdf.

21. 7 U.S.C. § 2543.

22. *See* Wegner, *supra* note 20, at 4–5.

23. *See id.*

24. *Cf.* 17 U.S.C. § 109(a) (2006); *Kirtsaeng v. John Wiley & Sons, Inc.*, 133 S. Ct. 1351, 1354–55 (2013); *Quality King Distribs., Inc. v. L'anza Research Int'l, Inc.*, 523 U.S. 135, 145 (1998). *See generally* R. Anthony Reese, *The First Sale Doctrine in the Era of Digital Networks*, 44 B.C. L. REV. 577 (2003).

25. *See Quanta Computer Inc. v. LG Elecs., Inc.*, 553 U.S. 617, 625–28 (2008); *United States v. Univis Lens Co.*, 316 U.S. 241, 250–51 (1942).

for reproductive purposes."[26] This exemption enabled farmers to sell PVPA-protected seeds in direct competition with breeders.

In 1992, the Federal Circuit allowed farmers to sell up to half of their harvests of PVPA-certified crops in "brown-bag" transactions with other farmers.[27] This permissive interpretation enabled an enterprising farmer, selling "only half of [each] crop . . . as seed in successive years," to flood the commercial seed market after three years with something "between 2,037 and 11,655 bushels of seed."[28] Because "a single bushel of soybean seed will produce between 25 and 45 bushels of soybeans[,] . . . a single soybean seed, after three crops, [will] produce 27,000 seeds."[29]

Both Congress and the Supreme Court eventually intervened. In 1994, Congress repealed the PVPA's brown-bagging exemption.[30] The Supreme Court's 1995 decision in *Asgrow Seed Co. v. Winterboer*[31] confined brown-bag sales under the pre-1994 version of the PVPA to "only such seed as [a farmer] has saved for the purpose of replanting his own acreage."[32] This case "signaled a shift in enforcement of plant intellectual property rights from litigation against corporate competitors to lawsuits against the end-user farmer."[33]

Since 1994, the PVPA has conferred no brown-bagging privileges on farmers. In its current form, the PVPA exempts only two farmer-specific activities from its definition of infringement. First, the PVPA protects

> [a] bona fide sale for other than reproductive purposes, made in channels usual for such other purposes, of seed produced on a farm either from seed obtained by authority of the owner for seeding purposes or from seed produced by descent on such

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26. Plant Variety Protection Act, Pub. L. No. 91-577, § 113, 84 Stat. 1542, 1555 (1970).

27. *See Asgrow Seed Co. v. Winterboer*, 982 F.2d 486, 489–91 (Fed. Cir. 1992), *rev'd*, 513 U.S. 179 (1995).

28. *Id.* at 480 n.2 (Newman, J., dissenting from denial of rehearing *en banc*).

29. *Id.*

30. *See* Plant Variety Protection Act Amendments of 1994, Pub. L. No. 103-349, § 10, 108 Stat. 3136, 3142 (1994) (amending 7 U.S.C. § 2543); *Asgrow Seed Co.*, 513 U.S. at 184 n.2 (acknowledging the repeal of the brown-bagging provisions of the PVPA). *See generally* H.R. REP. NO. 103-699, 8–10, 14–15 (1994) (describing Congress's reasons for repealing the brown-bagging provisions), *reprinted in* 1994 U.S.C.C.A.N. 2423, 2430–31; 139 CONG. REC. S10841, S10,872 (daily ed. Aug. 6, 1993) (UPOV references by Sen. Herb Kohl, sponsor of the amendment to eliminate brown-bagging from the PVPA).

31. 513 U.S. 179 (1995).

32. *Id.* at 192.

33. Rita S. Heimes, *Post-Sale Restrictions on Patented Seeds: Which Law Governs?*, 10 WAKE FOREST INTELL. PROP. L.J. 98, 109 (2010).

> farm from seed obtained by authority of the owner for seeding purposes.[34]

That provision's implicit immunity for seed saving, at least when permitted by the seller of the seed, is made explicit in the PVPA's protection of bin run:

> Except to the extent that such action may constitute an infringement under subsections (3) and (4) of section 2541 of this title, it shall not infringe any right hereunder for a person to save seed produced by the person from seed obtained, or descended from seed obtained, by authority of the owner of the variety for seeding purposes and use such saved seed in the production of a crop for use on the farm of the person, or for sale as provided in this section.[35]

B. Seed-Wrap Licensing

Contractual limitations on seeds have emerged even as statutory rights to save seed have receded. Plant breeders routinely require purchasers of PVPA-protected seed to waive their seed-saving rights through "seed-wrap" or "bag-tag" licenses printed on or attached to a bag of seed.[36] Seed-wrap licenses also accompany seeds protected by a utility patent.[37] In either instance, the plant breeder is using contract to privately secure rights akin to those ordinarily conferred through intellectual property legislation or, with respect to seed protected under the PVPA, to restore the breeder's legal control over plant genetics.[38] Seed-wrap licenses routinely prohibit the "[r]esale of . . . seed or supply of saved seed to anyone, including [the] [p]urchaser, for planting;" the "[u]se of [the] product, or the parental lines used in producing [the] product, for use in development or breeding;" and

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34. 7 U.S.C. § 2543 (2012).

35. *Id.* § 2543.

36. *See* Dan L. Burk, *DNA Rules: Legal and Conceptual Implications of Biological "Lock-Out" Systems*, 92 CALIF. L. REV. 1553, 1557–58 (2004); Neil D. Hamilton, *Legal Issues Shaping Society's Acceptance of Biotechnology and Genetically Modified Organisms*, 6 DRAKE J. AGRIC. L. 81, 107 (2001); Neil D. Hamilton, *Why Own the Farm if You Can Own the Farmer (and the Crop)?: Contract Production and Intellectual Protection of Grain Crops*, 73 NEB. L. REV. 48, 90–94 (1994) [hereinafter Hamilton, *Why Own the Farm*].

37. *See, e.g.*, Hamilton, *Why Own the Farm*, *supra* note 36, at 91.

38. *See* J.H. Reichman & Jonathan A. Franklin, *Privately Legislated Intellectual Property Rights: Reconciling Freedom of Contract with Public Good Uses of Information*, 147 U. PA. L. REV. 875, 877–78 (1999).

the use of "any parental seed that might be unintentionally contained . . . for purposes of producing forage, or grain for feeding or processing."[39]

In the dozen years preceding the Supreme Court's 2013 decision in *Bowman v. Monsanto Co.*, the Federal Circuit entertained and rejected a wide variety of attacks on seed-wrap licensing. In a pair of cases, both styled *Monsanto Co. v. McFarling*,[40] the Federal Circuit ruled against a farmer who had saved patented Roundup Ready® soybean seed and planted it in a subsequent growing season in violation of Monsanto's licensing agreement.[41]

In the 2002 case of *McFarling I*,[42] Homan McFarling, a Mississippi soybean farmer, attacked Monsanto's licensing agreement as "an illegal tying arrangement" that "requir[ed] farmers to buy new Roundup Ready® seed each year instead of allowing them to produce their own Roundup Ready® seed from the prior year's crop."[43] No tying arrangement existed, the Federal Circuit held, because the licensing agreement did not "prevent[] Mr. McFarling from switching to other soybean seeds" among the "over two hundred commercial sources of soybean seed, including several herbicide-resistant soybeans."[44] As a federal district court applying *McFarland I* later observed, farmers who purchase seed subject to a licensing agreement that prohibits saving and replanting "are not in the position of [a] new-car purchaser obliged to purchase a new car every year."[45] "Rather," such farmers "are in the position of a car-lessor crying foul upon discovering he cannot retain the car after his lease expires."[46]

McFarling I also rejected the argument that the PVPA's crop exemption, "which permits farmers to save seeds of plants registered under" that statute, vitiates "contractual prohibition[s] against using . . . patented soybeans to produce additional seeds for planting."[47] The Federal Circuit held "that the right to save seed . . . under the PVPA does not impart the right to save seed . . . under the Patent Act."[48]

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39. Janis & Kesan, *supra* note 8, at 772 (quoting a "representative example of the key licensing restrictions in a bag-tag license"); *see also Pioneer Hi-Bred Int'l v. Ottawa Plant Food, Inc.*, 283 F. Supp. 2d 1018, 1045–46 (N.D. Iowa 2003).

40. *McFarling I*, 302 F.3d 1291 (Fed. Cir. 2002), *cert. denied*, 537 U.S. 1232 (2003); *McFarling II*, 363 F.3d 1336 (Fed. Cir. 2004), *cert. denied*, 545 U.S. 1139 (2005).

41. *McFarling I*, 302 F.3d at 1293, 1299–1300; *McFarling II*, 363 F.3d at 1352.

42. 302 F.3d 1291 (Fed. Cir. 2002), *cert denied*, 537 U.S. 1232 (2003).

43. *Id.* at 1297.

44. *Id.* at 1298.

45. *Monsanto Co. v. Swann*, 308 F. Supp. 2d 937, 942 (E.D. Mo. 2003).

46. *Id.*

47. *McFarling I*, 302 F.3d at 1298–99.

48. *Id.* at 1299; *accord McFarling II*, 363 F.3d at 1344 ("Congress did not intend to prohibit owners of utility patents from enforcing seed-saving prohibitions in their licenses.").

Critics of seed-wrap licensing had urged heavy reliance on an analogy to the patent misuse doctrine.[49] The patent misuse doctrine is designed "to prevent a patentee from using [a] patent to obtain market benefit beyond that which inheres in the statutory patent right."[50] For instance, patent law forbids "bald attempt[s]" to extend the exclusivity period of a patent through contracts purporting "to exact the same terms and conditions" as the statutory grant.[51]

McFarling II,[52] decided in 2004, reformulated McFarling's tying claim as one "center[ed] on his desire to replant the entire seed" derived from the original bag of Roundup Ready® soybeans "and on Monsanto's refusal to grant him permission to do so."[53] McFarling proposed that farmers be allowed to "save and replant Roundup Ready® seed each year" upon payment of a technology fee in lieu of the existing arrangement by which farmers "purchase both the seed and the genetic technology together at the beginning of each growing season."[54]

The Federal Circuit declined McFarling's invitation to establish "a compulsory license to use the patent rights in conjunction with . . . second-generation Roundup Ready® soybeans."[55] *McFarling II* did not "hold that Monsanto's raw exercise of its right to exclude from the patented invention by itself is . . . 'tying.'"[56] Although the court stopped short of holding that the licensing agreement imposed "permissible field-of-use restrictions on the first-generation seeds,"[57] it did sustain the seed-saving prohibition on the reasoning that Monsanto's Roundup Ready® patent would embrace "all generations of soybeans produced."[58] Any restriction "prohibiting the replanting of" any subsequent "generation of Roundup Ready® soybeans" would accordingly "not extend Monsanto's rights under the patent statute."[59]

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49. *See, e.g.*, Burk, *supra* note 36, at 1569.

50. *Mallinckrodt, Inc. v. Medipart, Inc.*, 976 F.2d 700, 704 (Fed. Cir. 1992); *see also Carbice Corp. of Am. v. Am. Patents Dev. Corp.*, 283 U.S. 27, 30–31 (1931); *Senza-Gel Corp. v. Seiffhart*, 803 F.2d 661, 665 (Fed. Cir. 1986).

51. *Brulotte v. Thys Co.*, 379 U.S. 29, 32 (1964) (declaring contracts of this sort "unlawful *per se*").

52. 363 F.3d 1336 (Fed. Cir. 2004), *cert. denied*, 545 U.S. 1139 (2005).

53. *Id.* at 1342.

54. *Id.*

55. *Id.*; *see also id.* at 1344 ("McFarling is not alleging that he is unable to, or even that he desires to, purchase a 'natural' soybean seed and the Roundup Ready® genetic trait as distinct items; he alleges only that Monsanto refuses to grant him a license to use the second-generation . . . seeds . . . in his preferred manner.").

56. *Id.* at 1342.

57. *Id.*

58. *Id.* at 1343.

59. *Id.*

The tying argument in *McFarling II* would fare no better as an independent antitrust claim. In the 2006 case of *Monsanto Co. v. Scruggs*,[60] the Federal Circuit again rejected an attack on the alleged tying of Monsanto's Roundup Ready® gene in cotton to the plant-incorporated protectant (*Bacillus thuringiensis*, or Bt, a naturally insecticidal bacterium) coded in Monsanto's stacked-trait cotton variety, Bollgard®.[61]

C. Chasing Selfs: The Reverse Engineering of Hybrid Seed

Bin run and brown-bagging are largely artifacts of plant reproduction. Crops such as wheat, soybeans, and cotton—which self-pollinate and reproduce true-to-type—are strong candidates for seed saving. A single generation of seed will provide multiple seasons of planting before losing ground to genetic drift.[62] Cross-pollinated hybrid crops, such as corn, sorghum, and sunflowers, are a different matter. Because these crops lose hybrid vigor after a single planting, farmers must buy new seed each planting season.[63] Thanks to this inherent protection—and the willingness of courts to protect the parentage of hybrid crops as trade secrets[64]—hybrids over the course of the twentieth century became "the predominant

60. 459 F.3d 1328 (Fed. Cir. 2006).

61. *See id.* at 1340–41. On the patentability of each independent gene sequence in a stacked-trait plant variety, see Andrew W. Torrance, *Intellectual Property as the Third Dimension of GMO Regulation*, 16 KAN. J.L. & PUB. POL'Y 257, 279 (2007).

62. *See generally* Joanna Masel, *Genetic Drift*, 21 CURRENT BIOLOGY R837, R837 (2011), *available at* http://www.sciencedirect.com/science/article/pii/S0960982211008827.

63. *See* JORGE FERNANDEZ-CORNEJO, THE SEED INDUSTRY IN U.S. AGRICULTURE: AN EXPLORATION OF DATA AND INFORMATION ON CROP SEED MARKETS, REGULATION, INDUSTRY STRUCTURE, AND RESEARCH AND DEVELOPMENT 2 (2004) (U.S. Department of Agriculture, Economic Research Service, Agriculture Information Bulletin No. AIB-786) ("[T]he enhanced vigor of hybrid seed is not transmitted to its offspring, thereby requiring farmers to buy new seed every year to ensure continued vigor. Crops cultivated from seed saved from a hybrid crop grown in the previous year are typically less vibrant and significantly lower in yield."). *See generally* S.J. Owens, *Pollination and Fertilization in Higher Plants*, *in* FRUIT AND SEED PRODUCTION: ASPECTS OF DEVELOPMENT, ENVIRONMENTAL PHYSIOLOGY AND ECOLOGY 33 (C. Marshall & J. Grace eds., 1992); G.F. Sprague, *Hybrid Corn*, *in* AFTER A HUNDRED YEARS: YEARBOOK OF AGRICULTURE, 1962, at 106–07 (U.S. Department of Agriculture 1962).

64. *See Pioneer Hi-Bred Int'l v. Holden Found. Seeds, Inc.*, 35 F.3d 1226, 1235 (8th Cir. 1994) ("[W]e assume without deciding that genetic messages can qualify for trade secret status."); *see also id.* at 1236 n.37 (repeating the court's assumption that "the genetic message contained" in a plant breeder's "inbred lines" of corn "is protected by trade secret law"). *See generally* Debra L. Blair, *Intellectual Property Protection and Its Impact on the U.S. Seed Industry*, 4 DRAKE J. AGRIC. L. 297, 308–10 (1999); Keith D. Parr, *Developments in Agricultural Biotechnology*, 19 WM. MITCHELL L. REV. 457, 469–71 (1993).

form of cultivar in many crops."[65] Hybrid corn, for instance, begins with the development of two inbred lines "by self-pollination and selection until [each] line is relatively homozygous."[66] The use of pollen from the male inbred line to fertilize silks on the female inbred line then produces hybrid seed.[67]

The ease with which crops can be produced commercially on a hybrid basis is a function of plant biology. Different angiosperms (flowering plants) have fluctuated between outcrossing and self-pollination as reproductive strategies throughout their evolutionary history.[68] Traditionally associated with allogamous, or cross-pollinating, crops such as "maize, sunflower, brassicas, cucurbits, carrots, beets, and onions," the use of hybrid cultivars has become common even "in certain autogamous [self-pollinating] crops, including sorghum, tomato, and peppers" and in the production of allogamous crops in nonindustrialized countries.[69] Plant breeders readily "exploit[] heterosis" in corn "by growing exceptionally heterotic F_1 single-cross hybrids between carefully selected inbred lines (single-cross hybrids) in commercial production."[70] Breeders do this precisely because

> selfing [in corn] is easy, because many modern selfed lines are easy to maintain and reasonably productive, and [because] large-scale hybridizations between pairs of selfed lines can be achieved by interplanting pairs of inbred lines and, at flowering, detasseling one or the other of the inbred lines mechanically, or by taking advantage of one or another sterility mechanisms [*sic*] to obtain hybrids in mixed plantings.[71]

So-called synthetic varieties enable commercially valuable hybridization of alfalfa, while exploitation of male sterility has facilitated single-cross hybrids of even self-pollinating crops such as sorghum.[72]

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65. Arnel R. Hallauer, *Breeding Hybrids*, *in* ENCYCLOPEDIA OF PLANT AND CROP SCIENCE 186, 186 (Robert M. Goodman ed., 2004).

66. *Pioneer*, 35 F.3d at 1228 n.2; *accord id.* at 1236 n.38.

67. *See id.* at 1228 n.2. *See generally* Hallauer, *supra* note 65, at 187 (describing the development and deployment of hybrid corn); A.R. Hallauer, Wilbert A. Russell & K.R. Lamkey, *Corn Breeding*, *in* CORN AND CORN IMPROVEMENT 463 (G.F. Sprague & J.W. Dudley eds., 3d ed. 1988).

68. *See generally* Spencer C.H. Barrett, *Mating Strategies in Flowering Plants: The Outcrossing-Selfing Paradigm and Beyond*, 358 PHIL. TRANS. ROYAL SOC'Y LONDON B 991, 991–92 (2003).

69. Hallauer, *supra* note 65, at 186.

70. ROBERT W. ALLARD, PRINCIPLES OF PLANT BREEDING 37 (2d ed. 1999).

71. *Id.*

72. *Id. See generally* D.W. Denna, *The Potential Use of Self-Incompatibility for Breeding F_1 Hybrids of Naturally Self-Pollinated Vegetable Crops*, 20 EUPHYTICA 542

Hybrid crops nevertheless remain vulnerable to an insidious, if clever, form of reverse engineering. Heterosis, or hybrid vigor, holds the key to hybrid crops' superior performance.[73] It also opens a back door to their underlying genetic secrets. Despite all precautions, each bag of hybrid seeds contains a small amount of inbred seeds. The "genetic purity of [a] breeder's seed . . . can be maintained by growing the crop in isolation and by rigorous roguing during different phases of crop growth."[74] Genetic purity "can be further enhanced by bulk selection, wherein 2000–2500 plants typical of the variety are selected, harvested, and threshed separately" so that "off-types, if any," may be discarded and the remaining "uniform seeds are bulked to constitute breeders seed."[75] Planting the resulting inbred seeds, or "selfs," reproduces the parent lines true-to-type.[76]

With sufficient patience and land, a competing plant breeder, a farmer, or an academic researcher can use the technique of "chasing the selfs" to unlock the inbred parent lines of a hybrid variety. Planting all the seeds from a bag of hybrid seed in a configuration that puts adequate space between plants facilitates ready identification of any inadvertently included inbreds. Lacking heterosis, inbred plants look different from the taller hybrids.[77] Their leaves and tassels are smaller, and the plants themselves are shorter. The aesthetics of modern monocultures enables any farmer or plant

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(1971) (describing the inducement of self-incompatibility, through male sterility or otherwise, and efficient pollen transfer as prerequisites to the development of F_1 hybrids of naturally self-fertilized crops). The term "F_1 hybrid" refers to the first filial generation of offspring of distinctly different parental types. *See* MARSCHALL S. RUNGE & CAM PATTERSON, PRINCIPLES OF MOLECULAR MEDICINE 58 (2d ed. 2006). Most agricultural cultivars are intraspecific F_1 hybrids, developed by crossing two inbred lines within a single plant species with the goal of achieving heterosis, or greater vigor than either of the parental lines. *See, e.g.*, Stella Galanopoulou-Sendouca & Demetrios Roupakias, *Performance of Cotton F_1 Hybrids and Its Relation to the Mean Yield of Advanced Bulk Generations*, 11 EUR. J. AGRONOMY 53 (1999); B. Lelou et al., *A Study of Intraspecific Hybrid Lines Derived from the Reciprocal Crosses between Wild Accessions and Cultivated Cowpeas (*Vigna unguiculata *(L.) Walp.)*, 5 AFR. J. PLANT SCI. 337 (2011).

73. *See generally* Kendall R. Lamkey & Jode W. Edwards, *Breeding Plants and Heterosis*, *in* ENCYCLOPEDIA OF PLANT AND CROP SCIENCE, *supra* note 65, at 189 ("Heterosis may be one of the most important biological concepts to emerge from the 20th century because of its fundamental role in the hybrid corn industry.").

74. B.B. DESAI ET AL., SEEDS HANDBOOK: BIOLOGY, PRODUCTION, PROCESSING, AND STORAGE 136 (1997).

75. *Id.*

76. *See* Lamkey & Edwards, *supra* note 73, at 189 ("Selfing [or self-fertilizing] the individual plants of [an] open-pollinated variety to homozygosity would result in the fixation of the individual gametes in the population in inbred lines."). "Selfs" are seeds from self-pollinated inbred plants used to develop F_1 (filial one) intraspecific hybrid crop cultivars. *See* ROLF H.J. SCHLEGEL, ENCYCLOPEDIC DICTIONARY OF PLANT BREEDING AND RELATED SUBJECTS 224, 341 (2003).

77. *See, e.g.*, DESAI ET AL., *supra* note 74, at 548; *see also* Hallauer, *supra* note 65, at 186.

breeder to spot the difference: "A corn field planted from single-cross [hybrid] seed is impressive because the plants tend to be uniform. Plant height, ear height, tasseling, silking, and pollen shedding are uniform, giving the field good eye appeal."[78] Plants from the inbred parent lines reveal themselves as deviant specimens.

In *Pioneer Hi-Bred International v. Holden Foundation Seeds, Inc.*,[79] the case most often cited as recognizing the possibility of protecting the parentage of hybrid crops as a trade secret, the breeder asserting property in hybrid corn "presented no direct evidence regarding how Holden," a competing plant breeder, obtained proprietary germplasm.[80] But the founder of Holden admitted to "searching 'friendly farms' for stray inbred plants" and thereby "obtaining possession of several Pioneer lines."[81] That revelation in *Pioneer* can only be understood as an instance of reverse engineering through the exploitation of chasing selfs.

The significance of this conclusion cannot be overstated. The law of trade secrets ordinarily "does not offer protection against discovery by fair and honest means."[82] The law allows competitors to exploit "independent invention, accidental disclosure, or . . . so-called reverse engineering, that is by starting with the known product and working backward to divine the process which aided in its development or manufacture."[83] *Pioneer* effectively characterizes the chasing selfs technique as an improper exploitation "of a mistaken or accidental disclosure of [a trade] secret," as opposed to the "uncovering [of a] trade secret through legitimate, publicly available means, . . . within the scope of permissible reverse engineering."[84] For its part, Pioneer Hi-Bred has resolved multiple lawsuits alleging that its competitors used the chasing selfs technique to violate Pioneer's intellectual property rights.[85] Any theoretical limit on the protection of

78. LAWRENCE O. COPELAND & MILLER B. MCDONALD, PRINCIPLES OF SEED SCIENCE AND TECHNOLOGY 246 (4th ed. 2001).

79. 35 F.3d 1226 (8th Cir. 1994).

80. *Id.* at 1239.

81. *Id.*

82. *Kewanee Oil Co. v. Bicron Corp.*, 416 U.S. 470, 476 (1974).

83. *Id. See generally* Pamela Samuelson & Suzanne Scotchmer, *The Law and Economics of Reverse Engineering*, 111 YALE L.J. 1575 (2002).

84. Mark D. Janis, *Intellectual Property Issues in Plant Breeding and Plant Biotechnology*, *in* BIOTECHNOLOGY, GENE FLOW, AND INTELLECTUAL PROPERTY RIGHTS: AN AGRICULTURAL SUMMIT 1, 7 (Marshall A. Martin ed., 2002), *available at* http://www.agriculture.purdue.edu/arp/ag_summit.pdf.

85. *See, e.g.*, *Cargill, Inc. v. National Union Fire Ins. Co.*, No. A03-187, 2004 WL 51671 at *2 (Minn. Ct. App., Jan. 13, 2004) (resolving an insurance dispute arising from Cargill's attempt to develop new corn lines through "unauthorized experimentation─such as 'chasing selfs'"); *Cargill and Pioneer Announce Settlement of Lawsuit*, SEEDQUEST (May 16, 2000), http://www.seedquest.com/news/releases/usa/pioneer/n2682.htm (announcing the settlement of a suit alleging that Cargill

hybrid crops through trade secret appears to have been resolved in favor of breeders.

Indeed, the reverse engineering of hybrid crops through chasing selfs has become such an expected element of the plant breeding industry that patent applications now routinely recite descriptions of the chasing selfs technique as a method for the production of inbred plants.[86] The irony is rich, and the circle is complete: Heterosis, which motivates breeders to develop new varieties and farmers to adopt them, enables unscrupulous seed purchasers and competing breeders to reverse engineer hybrid plants. As breeders continue their uptake of utility patents as their intellectual property form of choice, the chasing selfs technique has completed its transformation from reverse engineering tactic into an affirmative element of a patent application.

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misappropriated corn seed from Pioneer Hi-Bred and announcing that Cargill had agreed to cease "engag[ing] in the practice of isolating parent seed from bags of . . . hybrid seed corn—a process known as 'chasing selfs'"); Dave Price, *Cargill Reaps Bitter Harvest in Pioneer Dispute: Company Agrees to Pay $100 Million, Admits Ethical Lapses in Hybrid Seed Ops*, FINANCE AND COMMERCE (May 17, 2000), http://web.archive.org/web/20041227151118/http://www.finance-commerce.com/recent_articles/051700b.htm; *Syngenta and DuPont Reach Agreement on Lawsuits*, DUPONT (Nov. 29, 2004), http://www.prnewswire.com/news-releases/syngenta-and-dupont-reach-agreement-on-lawsuits-75573532.html (announcing the settlement of a dispute alleging that Syngenta had "inappropriately acquired Pioneer proprietary genetic material . . . through a practice known as 'chasing selfs'").

86. The following passage from Inbred Corn Line BE9513, U.S. Patent No. 7,714,203 B1 (filed Oct. 6, 2006) (issued May 11, 2010), is typical:

> Both female and male inbred seed may occasionally be found within a commercial bag of hybrid seed. Chasing the selfs involves identifying inbred plants within a stand of corn that has been grown from a bag of hybrid corn seed. Once the seed is planted, the inbred plants may be identified and selected due to their decreased vigor, i.e., by their short stature, narrower leaves, and smaller tassels relative to the hybrid plants that grow from the hybrid seed which predominates in a commercial bag of hybrid seed. By locating the inbred plants, isolating them from the rest of the plants, and self-pollinating them (i.e., "chasing selfs"), a breeder can obtain an inbred line that is identical to an inbred parent used to produce the hybrid. . . .
>
> One having skill in the art will recognize that once a breeder has obtained inbred corn plant BE9513 by chasing selfs from a bag of hybrid seed, the breeder can then produce new inbred plants such as by sib-pollinating, i.e., crossing the inbred corn plant BE9513 with another inbred corn plant BE9513, or by crossing the inbred corn plant BE9513 with a hybrid corn plant obtained by the growing the collection of seed.

Id. at col.11 l.60–col.12 l.5, col.12 ll.24–30.; *see also* Inbred Corn Line 1AA001, U.S. Patent No. 8,581,061 B1, at col.11 ll.41–53, col.12 ll.5–11 (filed Oct. 21, 2009) (issued Nov. 12, 2013).

D. Yeoman Bowman: Saved Seed and Patent Exhaustion

These developments presaged the pivotal 2013 Supreme Court decision in *Bowman v. Monsanto Co.*[87] That case decided "whether a farmer who buys patented seeds may reproduce them through planting and harvesting without the patent holder's permission" by dint of "the doctrine of patent exhaustion."[88] According to the patent exhaustion doctrine, "the authorized sale of a patented article gives the purchaser, or any subsequent owner, a right to use or resell that article," but not the right "to make new copies of the patented invention."[89] *Bowman* held that exhaustion does not permit the saving of patented seed.[90]

Bowman plowed familiar legal ground. In *McFarling I*, the Federal Circuit had already held that Monsanto's seed-wrap licensing agreement did not violate patent law's exhaustion doctrine insofar as McFarling never sold "the new seeds grown from the original batch" of Roundup Ready® soybeans.[91] A federal district court had held in 2001 that a single-use licensing agreement falls "within the scope of [a] patent grant" on herbicide-resistance technology and that patent law's "doctrine of exhaustion does not bar [a] suit for infringement [where] the sale of . . . patented gene technology is expressly conditioned on the signing of [a] restrictive licensing agreement that prohibits the saving of seed and restricts the use of the seed to a single growing season."[92]

But *Bowman* was no ordinary seed-saving case. What distinguished *Bowman* from earlier controversies was Vernon Bowman's unorthodox method of acquiring Roundup Ready® seeds. Because a significant number of soybean farmers in Indiana and throughout the rest of the United States have adopted Roundup Ready® seeds,[93] Bowman accurately "anticipate[d] that many of the [commodity] soybeans" sold by a local elevator "would contain Monsanto's patented technology."[94] By "appl[ying] a glyphosate-based herbicide to . . . fields" planted with commodity soybeans, Bowman was able to harvest "a new crop of soybeans with the Roundup Ready trait."[95] In all, Bowman planted and harvested eight

87. 133 S. Ct. 1761 (2013).

88. *Id.* at 1764.

89. *Id.*

90. *Id.*

91. *Monsanto Co. v. McFarling* (*McFarling I*), 302 F.3d 1291, 1299 (Fed. Cir. 2002), *cert. denied*, 537 U.S. 1232 (2003).

92. *Monsanto Co. v. Trantham*, 156 F. Supp. 2d 855, 870 (W.D. Tenn. 2001).

93. According to United States Department of Agriculture and private-sector data, "[m]ore than 90% of America's soybean fields contain beans with the Roundup Ready trait." Lim, *supra* note 14, at 150.

94. *Bowman*, 133 S. Ct. at 1765.

95. *Id.*

soybean crops derived from saved seeds and glyphosate-resistant commodity seeds that had survived his annual sieve of phytotoxicity.[96]

The Supreme Court swiftly dispatched Bowman's claim that the patent exhaustion doctrine would enable him "to make *additional* patented soybeans without Monsanto's permission (either express or implied)."[97] To hold otherwise would have conferred "scant benefit" on Monsanto as the inventor of the Roundup Ready® trait.[98] After receiving some reward on its first sale of Roundup Ready® seeds, Monsanto would watch "other seed companies . . . reproduce the product and market it to growers."[99] The "farmers themselves" would "buy the seed [only] once, whether from Monsanto, a competitor, or . . . a grain elevator," thereby enabling themselves to "multiply [that] initial purchase, and then multiply that new creation, *ad infinitum*."[100] The Court rejected Bowman's plea to apply the exhaustion doctrine without exception to "patented seeds and other 'self-replicating technologies.'"[101] Although the Court declined to speculate how patent exhaustion might govern other "situation[s] . . . involving a self-replicating product," it concluded that the exhaustion doctrine "provides no haven for . . . conduct" that "depriv[es]" the inventor "of the reward patent law provides for the sale of each article."[102]

Bowman falls squarely within a legal trajectory that connects UPOV and the original version of the PVPA with seed-saving controversies such as *Asgrow v. Winterboer*, the *McFarling* cases, and *Pioneer v. Holden*. Each of these cases exposed the market-destroying potential of a seed-saving or reverse-engineering practice. Planting for nonreproductive use—eating, feeding, or milling—is the very purpose of all seed, without regard to its degree of genetic modification. Bin run is the traditional agrarian practice that UPOV, the United Nations' seed treaty, and the PVPA have all sought to protect. Bin run enables farmers to make a single purchase of proprietary seed and to save enough from each harvest to plant the next crop. But bin run's reduction of plant breeders' opportunity for profit to a single sale to each farmer has aligned every other source of law, from seed-wrap licensing to trade secret and the Patent Act, against even this most modest form of seed saving.

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96. *See id.*

97. *Id.* at 1766.

98. *Id.* at 1767.

99. *Id.*

100. *Id.*

101. *Id.* at 1768 (quoting Brief for Petitioner at 16, *Bowman v. Monsanto Co.*, 133 S. Ct. 1761 (2013) (No. 11-796)).

102. *Id.* at 1769. *See generally* Jeremy N. Sheff, *Self-Replicating Technologies*, 16 STAN. TECH. L. REV. 229 (2013).

All other seed-saving practices constitute naked attacks on the profitability of seed breeding. Brown-bag sales enable farmers to compete directly against breeders as vendors of engineered seed. If defined as permissible reverse engineering rather than unlawful infringement, the discovery of hybrid crops' inbred parent lines through the chasing selfs technique would erase any benefit from the protection of hybrid plant varieties as trade secrets. Vernon Bowman's eight crops of glyphosate-resistant soybeans, all drawn from commodity beans to the exclusion of licensed sales by Monsanto or an authorized dealer, testify vividly to the wicked cleverness of Bowman's evasion of the Roundup Ready® patent. The sheer breadth of his claim under patent law's exhaustion doctrine raised the very conflict between seed saving and biotechnological innovation that a federal appeals court recognized in the context of the PVPA:

> While the main body of the Act assures developers of novel varieties the exclusive right to sell and reproduce that variety, the crop exemption dilutes that exclusivity by allowing individual farmers to sell the protected variety without liability. The broader the construction given the exemption, the smaller the incentive for breeders to invest the substantial time and effort necessary to develop new strains. The less time and effort that is invested, the smaller the chance of discovering superior agricultural products.[103]

II. THE NATURE OF THE FARM: AN INDUSTRIALIST MANIFESTO

This much is evident from the foregoing summary of the law of saved seed: an immense amount of energy—on farms, in laboratories, and in law offices—has been devoted to finding ways for farmers to save seed rather than having to buy new seed each season. This obsession has inflicted deep harm on agricultural innovation. Lingering uncertainty over the ability to enforce single-use restrictions on engineered seed has driven biotechnology companies to develop hybrid crops at the expense of crops reproducing true-to-type.[104] Motivating inventors to rely on the law of trade secrets rather than the PVPA or patent law defeats the broader constitutional interest in "the Progress of Science and useful Arts."[105] Either through the Patent Act's requirement of a "written

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103. *Delta & Pine Land Co. v. Peoples Gin Co.*, 694 F.2d 1012, 1016 (5th Cir. 1983).

104. *See* Lim, *supra* note 14, at 173; Sheff, *supra* note 102, at 245.

105. U.S. CONST. art. I, § 8, cl. 8.

description"[106] and an enabling disclosure,[107] or through the PVPA's relatively modest request for "a description of the variety setting forth its distinctiveness, uniformity, stability, and . . . genealogy and breeding procedure (when known),"[108] disclosures by plant breeders fulfill intellectual property law's "ultimate goal" of "bring[ing] new designs and technologies into the public domain."[109]

Absent more secure intellectual property rights for their inventions, biotechnology companies face strong incentives to devise genetic use restriction technologies (GURTs), the biological equivalent of anti-circumvention and digital rights management software.[110] Because every investment in GURTs diverts resources that could have been aimed at improving crops' agronomic and nutritional attributes, the whole enterprise reeks of enforcing legal rights at the expense of actual innovation.[111] The inclusion of GURTs in new crops will retard future dissemination, when those crops' underlying patents expire (as they eventually must) and biotechnology rather than law stands as the greatest barrier to the diffusion and uptake of new technology. Meanwhile, significant issues involving the most popular lines of bioengineered

106. 35 U.S.C. § 112(a) (2006 & Supp. V 2011).

107. *See, e.g.*, *Genentech, Inc. v. Novo Nordisk A/S*, 108 F.3d 1361, 1365 (Fed. Cir. 1997); *In re Wands*, 858 F.2d 731, 736–37 (Fed. Cir. 1988); *Hybritech, Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 1384 (Fed. Cir. 1986); *In re Wertheim*, 541 F.2d 257, 262–63 (C.C.P.A. 1976).

108. 7 U.S.C. § 2422(2) (2012); *accord J.E.M. Ag Supply, Inc. v. Pioneer Hi-Bred Int'l, Inc.*, 534 U.S. 124, 142–43 (2001). The PVPA also requires that applicants for protection deposit and "replenish[] periodically" a "viable sample of basic seed . . . in a public repository" in order to ensure "propagation of the variety." 7 U.S.C. § 2422(4) (2012); *see also* 7 C.F.R. § 97.6(d)(1) (2013); *J.E.M.*, 534 U.S. at 143. The PVPA demands a lower-quality disclosure than the fully descriptive and enabling disclosure required of patent applicants, in exchange for a weaker level of proprietary protection. *See* Mark D. Janis & Jay P. Kesan, *Designing the Optimal Intellectual Property System for Plants: A U.S. Supreme Court Debate*, 19 NATURE BIOTECH. 981, 982 (2001).

109. *Bonito Boats, Inc. v. Thunder Craft Boats, Inc.*, 489 U.S. 141, 151 (1989).

110. *See, e.g.*, Dan L. Burk, *Lex Genetica: The Law and Ethics of Programming Biological Code*, 4 ETHICS & INFO. TECH. 109, 111–12 (2002); Jason Savich, Monsanto v. Scruggs*: The Negative Impact of Patent Exhaustion on Self-Replicating Technology*, 22 BERKELEY TECH. L.J. 115, 128–29 (2007); Elizabeth I. Winston, *A Patent Misperception*, 16 LEWIS & CLARK L. REV. 289, 294–96 (2012); Jeremy P. Oczek, Note, *In the Aftermath of the "Terminator" Technology Controversy: Intellectual Property Protections for Genetically Engineered Seeds and the Rights to Save and Replant Seed*, 41 B.C. L. REV. 627, 628–29 (2000).

111. *Hear* INDIGO GIRLS, *Devotion*, *on* RETROSPECTIVE (Sony 2000) ("I've had enough temporary acquisition / Building fences for no gain"). In fairness to GURTs, the ability to render transgenic crops sterile after a single growing season has gained renewed appeal as a way of controlling the contamination of other plants, especially organic crops, with engineered traits. *See* Heidi Ledford, *Seed-Patent Case in Supreme Court*, NATURE, Feb. 2013, at 289–90; Lim, *supra* note 14, at 181–83.

crops elude satisfactory legal resolution, partly because farmers and their advocates persist in treating the disruption of biotechnology companies' profits as a surrogate for direct, meaningful engagement of uncomfortable environmental issues in agriculture.

Farmers have traditionally regarded their farms as environmentally and economically self-contained enterprises.[112] Once established, a farm should supply its own inputs, from seed for the next planting season to fertilizer derived from animal waste. But the history of all hitherto existing agriculture is the history of vertical integration and coordination.[113] Agriculture has always endured progressive rounds of technological innovation and uptake, accompanied by economic and social disruption on and off the farm.

In 1949, at the dawn of the Green Revolution,[114] the Supreme Court recognized the inevitability of technological transformation in agriculture:

> Agriculture, as an occupation, includes more than the elemental process of planting, growing and harvesting crops. . . . Whether a particular type of activity is agricultural depends, in large measure, upon the way in which that activity is organized in a particular society. . . . In less advanced societies the agricultural function includes many types of activity which, in others, are not agricultural. The fashioning of tools, the provision of fertilizer, the processing of the product, to mention only a few examples, are functions which, in some societies, are performed on the farm by farmers as part of their normal agricultural routine. Economic progress, however, is characterized by a progressive division of labor and separation of function. Tools are made by a tool manufacturer, who specializes in that kind of work and supplies them to the farmer. The compost heap is replaced by factory-produced fertilizers. Power is derived from electricity and gasoline rather than supplied by the farmer's mules. Wheat is ground at the

112. *Compare* MARTY STRANGE, FAMILY FARMING: A NEW ECONOMIC VISION 35 (new ed. 2008) (describing family farms as "resource conserving"), *with id.* at 38 (describing "industrial agribusiness" as "resource consumptive" because corporate farming "has no heirs").

113. *Cf.* KARL MARX & FRIEDRICH ENGELS, THE COMMUNIST MANIFESTO 3 (David McLellan ed., Oxford World's Classics 2008) (1848) ("The history of all hitherto existing society is the history of class struggles."). For an argument that American agriculture is not too Marxist, but rather not Marxist enough, see Jim Chen, *The American Ideology*, 48 VAND. L. REV. 809, 822 (1995).

114. *See generally* H.K. JAIN, GREEN REVOLUTION: HISTORY, IMPACT AND FUTURE (2010).

> mill. In this way, functions which are necessary to the total economic process of supplying an agricultural product, become, in the process of economic development and specialization, separate and independent productive functions operated in conjunction with the agricultural function but no longer a part of it.[115]

In the nearly contemporaneous case of *Wickard v. Filburn*,[116] arguably the most important agricultural law case in American history,[117] the Supreme Court likewise acknowledged the link between technological innovation on the farm and economic upheaval throughout society. Wheat that "is never marketed . . . supplies a need of the man who grew it which would otherwise be reflected by purchases in the open market."[118] The price support program upheld in *Filburn* "forc[ed] some farmers into the market to buy what they could provide for themselves" and represented "an unfair promotion of the markets and prices of specializing wheat growers."[119] There is no stronger legal endorsement of Ronald Coase's Nobel Prize-winning observation that vertical integration and open-market purchases are flip sides of the same economic phenomenon.[120]

In legal terms, these Supreme Court controversies presented Coase's key economic question: "Why is not all production carried on by one big firm?"[121] By 1957, Harvard economists invented a new word—"agribusiness"—to describe "the sum total of *all* operations involved in the manufacture and distribution of farm supplies; production operations on the farm; and the storage, processing, and distribution of farm commodities and items made from them."[122] Traditional agriculture—"more or less a self-contained industry" characterized by "typical farm famil[ies]" that "produced [their] own food, fuel, shelter, draft animals, feed, tools, and implements and even most of [their] clothing"—was rapidly disappearing.[123] Marginal farms folded, average farm size mushroomed,

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115. *Farmers Reservoir & Irrigation Co. v. McComb*, 337 U.S. 755, 760–61 (1949).

116. 317 U.S. 111 (1942).

117. *See generally* Jim Chen, Filburn*'s Legacy*, 52 EMORY L.J. 1719 (2003); Jim Chen, *The Story of* Wickard v. Filburn*: Agriculture, Aggregation, and Commerce*, *in* CONSTITUTIONAL LAW STORIES 69 (Michael C. Dorf, ed., 2d ed. 2009).

118. *Filburn*, 317 U.S. at 128.

119. *Id.* at 129.

120. R.H. Coase, *The Nature of the Firm*, 4 ECONOMICA (N.S.) 386, 388, 392 (1937); *accord Leegin Creative Leather Prods., Inc. v. PSKS, Inc.*, 551 U.S. 877, 903 (2007).

121. Coase, *supra* note 120, at 394.

122. JOHN H. DAVIS & RAY A. GOLDBERG, A CONCEPT OF AGRIBUSINESS 2 (1957) (emphasis added).

123. *Id.* at 4.

and industry began performing "virtually all [the] operations relating to growing, processing, storing, and merchandising food and fiber" that had been "a function of the farm."[124] Vertical integration *on* the farm dictates vertical integration *of* the farm. Whence the nature of the firm, thither the destiny of the farm.[125]

Against this tide of truth stands a peculiar and puny form of agrarian exceptionalism. Seed, so the story goes, simply seems different. There is little if any controversy today over the reliance of farmers on off-farm sources for fertilizer, fuel, pesticides, and veterinary services and supplies. There are justifiably robust debates over organic production, no-till practices, integrated pest management, and subtherapeutic administration of antibiotics to farm animals. None of these controversies, however, has sparked accusations that a particular form of biotechnology has subjected farmers as a class to domination by agribusiness. "At the heart of [agrarian] liberty," as it were, lies the right to save seed and, with it, "the right to define one's own concept of existence, of meaning, of the universe, and of the mystery of human life."[126] "Beliefs about . . . matters" this intimate "could not define the attributes of [agrarian] personhood were they formed under [economic] compulsion."[127] Being forced to procure seed from off-farm sources, season after season, represents a unique affront to agrarian sensibilities.

Two instinctive reactions may explain why farmers have fought so hard to save seed. Intellectual property law gives no support to either of those instincts. First, farmers quite naturally (but just as erroneously) assume that seeds as chattels and seeds as code are one and the same. Consequently, farmers assume that their mastery of seeds as chattels, from planting through harvesting, entitles them to control the genetic information coded in seeds through decisions about whether to save or sell some portion of each crop.

But the embodiment of proprietary DNA—seed as code—in the physical vessel of seed as chattel does not unite the ownership of intellectual and physical property. In this respect, the farmer buying Roundup Ready® soybeans has no greater claim to save seed than the owner of "tangible property," such as the letters of J.D. Salinger, may assert over "the literary property rights" belonging to Salinger as the author of those letters.[128]

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124. *Id.* at 1.

125. *See generally* Douglas W. Allen & Dean Lueck, *The Nature of the Farm*, 41 J.L. & ECON. 343 (1998) (discussing the circumstances when farms are likely to turn into large industrial enterprises).

126. *Cf. Planned Parenthood v. Casey*, 505 U.S. 833, 851 (1992).

127. *Cf. id.*

128. *Salinger v. Random House, Inc.*, 811 F.2d 90, 94–95 (2d Cir. 1987).

The typical farmer's second instinctive basis for chafing at restrictions on seed saving fares no better. Cultivating crops from planting to harvest is hard work. The sweat of their brows, so it may be argued, confers upon farmers a moral, if not strictly legal, right to save seed. The Supreme Court has "emphatically rejected" any theory that would confer intellectual property rights through the sweat of the brow.[129] Whatever else the law might glean from the philosophy of John Locke,[130] the labor theory of property offers no basis for a right to save seed.

To be sure, seed can be lawfully saved—provided that it is not subject to patent or to contractual restrictions imposed by the breeder. Public varieties contain no such limits on seed saving. Thanks to their devotion to the ideology of agrarian self-sufficiency, most developers of organic and heirloom varieties eschew limits on seed saving. These seeds offer none of the traits that make proprietary varieties so popular. But they can be saved. For farmers whose self-actualization hinges on the ability to save seed, these varieties offer an emotional and philosophical refuge.

Disputes over the ownership of plant genetic material have sparked emotionally explosive battles, not least because narratives about agriculture and the environment dominate cosmological stories of origin.[131] The

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129. *Eldred v. Ashcroft*, 537 U.S. 186, 236 (2003) (Stevens, J., dissenting) (citing *Wheaton v. Peters*, 33 U.S. (8 Pet.) 591, 661 (1834)). *See generally Feist Publ'ns, Inc. v. Rural Tel. Serv. Co.*, 499 U.S. 340, 351–61 (1991).

130. These works offer some sense of the breadth of John Locke's influence on law and legal scholarship: Donna M. Byrne, *Locke, Property, and Progressive Taxes*, 78 NEB. L. REV. 700 (1999); Jeffrey M. Gaba, *John Locke and the Meaning of the Takings Clause*, 72 MO. L. REV. 525 (2007); Wendy J. Gordon, *A Property Right in Self-Expression: Equality and Individualism in the Natural Law of Intellectual Property*, 102 YALE L.J. 1533 (1993); Adam Mossoff, *Locke's Labor Lost*, 9 U. CHI. L. SCH. ROUNDTABLE 155 (2002).

131. *See, e.g.*, JOHN STEINBECK, EAST OF EDEN 413 (1st ed. 1952) ("[T]here is one story in the world, and only one."); Milner S. Ball, *Stories of Origin and Constitutional Possibilities*, 87 MICH. L. REV. 2280 (1989); Robert M. Cover, *The Folktales of Justice: Tales of Jurisdiction*, 14 CAP. U. L. REV. 179, 180 & n.7 (1985) (describing the origins of law in "the sacred narratives of our world"). *Compare* Lynn White, Jr., *The Historical Roots of Our Ecological Crisis*, SCIENCE, Mar. 1967, at 1205–06 (describing the book of Genesis as the origin of the Judeo-Christian tradition's instrumental attitude toward nature), *with* John Copeland Nagle, *Playing Noah*, 82 MINN. L. REV. 1171, 1171–73 (1998) (describing the story of Noah as the Judeo-Christian basis for biodiversity conservation). *See generally* J. BAIRD CALLICOTT, EARTH'S INSIGHTS: A SURVEY OF ECOLOGICAL ETHICS FROM THE MEDITERRANEAN BASIN TO THE AUSTRALIAN OUTBACK 14 (1994) (identifying the "historical roots of . . . European . . . attitudes and values" on the environment); DAVID R. KINSLEY, ECOLOGY AND RELIGION: ECOLOGICAL SPIRITUALITY IN CROSS-CULTURAL PERSPECTIVE (1995); JOHN PASSMORE, MAN'S RESPONSIBILITY FOR NATURE: ECOLOGICAL PROBLEMS AND WESTERN TRADITIONS (1974); Jim Chen, *Of Agriculture's First Disobedience and Its Fruit*, 48 VAND. L. REV. 1261 (1995); Jim Chen, *Webs of Life: Biodiversity Conservation as a Species of Information Policy*, 89 IOWA L. REV. 495, 598–602 (2004); Judith M. Green, *Retrieving the Human Place in Nature*, 17 ENVTL. ETHICS 381, 389–93 (1995).

"intense spiritual feelings" derived from nature's "unfathomable complexity and . . . sublime beauty"[132] turn quickly into spite once humans attend the gritty business of making a living—or a killing—from natural resources. "Rise, Peter; kill and eat."[133]

Agriculture invokes the mysteries of life.[134] The deceptively simple act of planting seed conceals an enterprise "so vast that fully to comprehend it would require an almost universal knowledge ranging from geology, biology, chemistry and medicine to the niceties of the legislative, judicial and administrative processes of government."[135] To understand seed saving and reverse engineering in the proper agricultural context, however, we must demystify the entire process. Seed saving imperils biotechnological innovation in agriculture, for no greater benefit than the putative independence of farmers.

The seed bridges several biological and metaphorical divides. Among drivers of evolution, two forces tower above all others. One of them is food. The other is sex. The seed is both. "It is both means of production and, as grain [or fruit], the product."[136] Seed as phenotype is a mere chattel, perhaps another organism's lunch.[137] Seed as genotype, however, is at once a set of instructions for assembling and operating a plant and a dynamic record of that plant's evolutionary history.[138] Ontogeny truly does

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132. DAVID TAKACS, THE IDEA OF BIODIVERSITY: PHILOSOPHIES OF PARADISE 255 (1996).

133. *Acts* 11:7 (Revised Standard Version).

134. *See* Georgie Starbuck Galbraith, *On a Seed*, in SEEDS: THE YEARBOOK OF AGRICULTURE, 1961, at xv (1961) (originally published May 6, 1960, in the N.Y. TIMES).

> This was the goal of the leaf and the root.
> For this did the blossom burn its hour.
> This little grain is the ultimate fruit.
> This is the awesome vessel of power.
>
> For this is the source of the root and the bud . . . .
> World unto world unto world remolded.
> This is the seed, compact of God,
> Wherein all mystery is enfolded.

Id.

135. *Queensboro Farms Prods., Inc. v. Wickard*, 137 F.2d 969, 975 (2d Cir. 1943).

136. JACK RALPH KLOPPENBURG, JR., FIRST THE SEED: THE POLITICAL ECONOMY OF PLANT BIOTECHNOLOGY, 1492–2000, at 10 (1988).

137. *See* Richard Dawkins & John R. Krebs, *Arms Races between and within Species*, 205 PROC. ROYAL SOC'Y LONDON: SERIES B, BIOL. SCIS. 489 (1979) (deriving the "life-dinner principle" from the observation that "a lineage under strong selection may out-evolve a weakly selected one" and using this insight to explain why prey animals often—and usually—elude their predators).

138. *See generally* ANTOINE DANCHIN, THE DELPHIC BOAT: WHAT GENOMES TELL US (Alison Quayle transl., 2002).

recapitulate phylogeny.[139] Programming genetic code into seeds further "blurs the line between law and artifact, and promises to challenge long-held assumptions in the legal regime of ownership and control over . . . biological creations."[140]

Seeds present no fewer problems for the law of intellectual property than do pharmaceutical products. Drugs are exceptionally susceptible to unauthorized duplication because they are durable, subject to intense demand, relatively inexpensive to produce, easily transported, and readily imitated at a minute fraction of the original research and development costs.[141] Drugs heed no "natural physical barriers that exclude potential consumers," "may be held by more than one person at a time," can be distributed at "minimal or nonexistent" cost, and, once disclosed, face "no real barriers to free appropriation."[142]

Seeds inject a further complication. At least in the case of self-pollinating plants, seeds reproduce of their own accord.[143] In other settings, "[t]echnology generally is used as a tool to make something else or as a component in making something else but not to make a new version of itself."[144] "Copying," a deviant and difficult deed in many other industries, is the definition of agriculture. Whether they cultivate plants or raise animals,[145] farmers specialize in inducing living organisms to reproduce.

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139. In plain language, "ontogeny recapitulates phylogeny" means that any individual organism's life cycle replays the entire evolutionary history of the species. Ernst Haeckel, who also coined the term "ecology," *see* STEPHEN JAY GOULD, ONTOGENY AND PHYLOGENY 76 n.* (1977), devised this convenient but sometimes misleading maxim. *Compare* GOULD, *supra*, at 76–78 (describing Haeckel's role in popularizing and in distorting Darwin's work), *with id.* at 202–06 (describing how Mendelian genetics undermined Haeckel and rehabilitated his rival, Karl Ernst von Baer).

140. Burk, *supra* note 36, at 1554–55.

141. *See* Otto A. Stamm, *GATT Negotiations for the Protection of New Technologies*, 73 J. PAT. & TRADEMARK OFF. SOC'Y 680, 685 (1991).

142. Dan L. Burk, *Protection of Trade Secrets in Outer Space Activity: A Study in Federal Preemption*, 23 SETON HALL L. REV. 560, 584–85 (1993); *see also* U.S. CONGRESS, OFFICE OF TECHNOLOGY ASSESSMENT, FINDING A BALANCE: COMPUTER SOFTWARE, INTELLECTUAL PROPERTY AND THE CHALLENGE OF TECHNOLOGICAL CHANGE 185 (1992) (explaining how "free riders" impede the efficient production of public goods).

143. *See* Lim, *supra* note 14, at 176.

144. Robin Feldman, *The Open Source Biotechnology Movement: Is It Patent Misuse?*, 6 MINN. J.L. SCI. & TECH. 117, 151 (2004).

145. In any biological context, brown bagging puts farmers in direct competition with breeders whose livelihood depends on devising genetic improvements and selling germplasm. At least one commentator has argued that the Patent Act should be amended, along the lines of the 1970 version of the PVPA, to grant farmers the right to sell the embryos and gametes of patented animals to other farmers on a "brown-bag" basis. *See* Robert P. Merges, *Intellectual Property in Higher Life Forms: The Patent System and Controversial Technologies*, 47 MD. L. REV. 1051, 1068–73 (1988).

Plant breeders therefore face two sources of competitive pressure whenever they release seed into the market. Not only must they fend off competing breeders, but every customer is also a potential rival.[146] Self-replication, in other words, "is an extreme form of self-disclosure."[147] As the prime example of a self-replicating technology, seeds "don't merely teach competitors how to practice a new invention"; they "supply . . . competitors with a factory."[148] "[C]onflict arises because every customer could become [a] competitor[] as the product replicates, potentially making every first sale the patentee's last."[149] "From the standpoint of a producer of innovation, the notion of a self-replicating invention presents as compelling a case for intellectual property intervention as can be imagined."[150]

III. THIS IS THE DAWNING OF THE AGE OF ORGANOPHOSPHORUS

Patent law is patently amoral.[151] In any of its guises, intellectual property law makes an exceptionally poor vehicle for addressing matters of "aesthetics and morals."[152] The Roundup Ready® trait at the heart of so many seed-saving controversies deserves close scrutiny. There are many reasons to condemn the prevalence—the utter ubiquity—of the American soybean industry's technological monoculture. The royalties that farmers must pay in the absence of a right to save seed do not rank among those reasons.

The transgenic modification of crops has occasioned a decrease in the application of chemical insecticides, coupled with a dramatic increase in the application of broad-spectrum herbicides.[153] One serious concern that seed-saving disputes have all but obscured is the ecological and evolutionary damage attributable to the nearly universal adoption of herbicide-resistant crops. In the 1980s, plant scientists discovered how to translate a mutation in the 5-enolpyruvylshikimate 3-phosphate synthase (EPSP synthase) gene in the bacterium *Salmonella typhimurium* into

146. *See* KLOPPENBURG, *supra* note 136, at 280.

147. Sheff, *supra* note 102, at 242 (emphasis removed).

148. *Id.*

149. Lim, *supra* note 14, at 133.

150. Janis & Kesan, *supra* note 8, at 730.

151. *See, e.g.*, *Juicy Whip, Inc. v Orange Bang, Inc.*, 185 F.3d 1364 (Fed. Cir. 1999).

152. R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 43 (1960) (observing that "problems of welfare economics must ultimately dissolve into a study of aesthetics and morals").

153. *See* Graham Brookes & Peter Barfoot, *Key Environmental Impacts of Global Genetically Modified (GM) Crop Use, 1996–2011*, 4 GM CROPS & FOOD 109, 110 (2013).

glyphosate tolerance in crop plants.[154] By 2013, 71 percent of all corn, 90 percent of all cotton, and 93 percent of all soybeans planted in the United States had been genetically engineered to resist herbicides.[155]

The alternative to blanket applications of broad-spectrum herbicide readily explains the popularity of herbicide-resistant crops. Herbicides and herbicide-resistant crops are substitutes for physical labor of the most demoralizing sort. Without herbicides, the farmer has no choice but to remove weeds by raw force. In the case of cotton, the physical alternative of chopping is particularly brutal:

> In order to produce a good cotton crop, cotton should be chopped in the summertime—the job simply involves chopping or hoeing the weeds out of the rows of growing cotton. It is a menial, unskilled task which requires no aptitude, no training, and no ability to reason. It is a work of drudgery . . . accomplished with a simple instrument—the hoe.[156]

James Agee, a giant of twentieth-century American literature, vividly expressed this sentiment:

> Chopping is a simple hard and hot job. It is simply thinning the cotton to a stand, hills a foot to sixteen inches apart, two to four stalks to the hill; done with an eight- to ten-inch hoeblade. You cut the cotton flush to the ground, with a semi-blow of the blade that aches first the forearms and in time the whole spine.[157]

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154. *See* L. Comai et al., *Expression in Plants of a Mutant* aroA *gene from* Salmonella typhimurium *Confers Tolerance to Glyphosate*, 317 NATURE 741 (1985); M. De Block et al., *Engineering Herbicide Resistance in Plants by Expression of a Detoxifying Enzyme*, 6 EMBO J. 2513 (1987); D. Llewellyn et al., *Genetic Engineering of Plants for Resistance to the Herbicide, 2,4-D*, *in* GENETIC ENGINEERING OF CROP PLANTS 67 (G.W. Lycett & D. Grierson eds., 1990); Elli Oxtoby & Monica A. Hughes, *Breeding for Herbicide Resistance Using Molecular and Cellular Techniques*, 40 EUPHYTICA 173 (1989); Dilip M. Shah et al., *Engineering Herbicide Tolerance in Transgenic Plants*, 233 SCIENCE 478 (1986); D.M. Stalker et al., *Expression in Plants of a Bromoxynil-Specific Bacterial Nitrilase That Confers Herbicide Resistance*, *in* GENETIC IMPROVEMENTS OF AGRICULTURALLY IMPORTANT CROPS: PROGRESS AND ISSUES 37 (Robert T. Fraley et al. eds., 1988).

155. *See* NAT'L AGRIC. STATISTICS SERV., AGRIC. STATISTICS BD., USDA, ACREAGE 33–34, 36–37 (2013), *available at* http://www.usda.gov/nass/PUBS/TODAYRPT/acrg0613.pdf.

156. *Castillo v. Givens*, 704 F.2d 181, 183–84 (5th Cir. 1983), *cert. denied*, 464 U.S. 850 (1983).

157. JAMES AGEE, COTTON TENANTS: THREE FAMILIES 131 (John Summers ed., 2013).

Glyphosate, the active ingredient in Monsanto's Roundup herbicide, arguably represents the leading cause for concern. Monocultures consisting of a single glyphosate-resistant crop variety, such as Roundup Ready® soybeans, invite multiple applications, season after season, of glyphosate. Repeated use of a single herbicide exerts intense selection pressure on plants and gives rise to herbicide-tolerant and herbicide-resistant "superweeds."[158] Almost immediately after Monsanto released seeds incorporating Roundup Ready® technology, the first cases of glyphosate resistance in rigid ryegrass (*Lolium rigidum*) were documented in Australia.[159] Glyphosate-resistant ryegrass has now been detected around the world.[160] Glyphosate resistance has been reported in Palmer amaranth, or pigweed (*Amaranthus palmeri*);[161] hairy fleabane, or buva (*Conyza bonariensis*);[162] horseweed (*Conyza canadensis*);[163] Johnsongrass (*Sorghum halepense*);[164] and goosegrass (*Eleusine indica*).[165]

In the case of common lambsquarters (*Chenopodium album*), a weed of special concern to corn and soybean farmers,[166] the discovery of

158. *See, e.g.*, Michael D.K. Owen & Ian A. Zelaya, *Herbicide Resistant Crops and Weed Resistance to Herbicides*, 61 PEST MGMT. SCI. 301 (2005).

159. *See* Stephen B. Powles et al., *Evolved Resistance to Glyphosate in Rigid Ryegrass (*Lolium rigidum*) in Australia*, 46 WEED SCI. 604 (1998).

160. *See* Christopher Preston et al., *A Decade of Glyphosate-Resistant* Lolium *around the World: Mechanisms, Genes, Fitness, and Agronomic Management*, 57 WEED SCI. 435, 435 (2009).

161. *See* A. Stanley Culpepper et al., *Glyphosate-Resistant Palmer Amaranth (*Amaranthus palmeri*) Confirmed in Georgia*, 54 WEED SCI. 620, 620 (2006).

162. *See* Martin M. Vila-Aiub et al., *Glyphosate-Resistant Weeds of South American Cropping Systems: An Overview*, 64 PEST. MGMT. SCI. 366 (2008); *see also* L. Vargas, et al., *Buva (*Conyza bonariensis*) Resistente ao Glyphosate na Região Sul do Brasil*, 25 PLANTA DANINHA 573 (2007).

163. *See* Xia Ge et al., *Rapid Vacuolar Sequestration: The Horseweed Glyphosate Resistance Mechanism*, 66 PEST. MGMT. SCI. 345 (2010), *corrected*, Xia Ge et al., *Erratum: Rapid Vacuolar Sequestration: The Horseweed Glyphosate Resistance Mechanism*, 66 PEST MGMT. SCI. 576 (2010); Clifford H. Koger et al., *Assessment of Two Nondestructive Assays for Detecting Glyphosate Resistance in Horseweed (*Conyza canadensis*)*, 53 WEED SCI. 438, 438 (2005).

164. *See* Martin M. Vila-Aiub et al., *Evolution of Glyphosate-Resistant Johnsongrass (*Sorghum halepense*) in Glyphosate-Resistant Soybean*, 55 WEED SCI. 566, 566 (2007).

165. Lim Jung Lee & Jeremy Ngim, *A First Report of Glyphosate-Resistant Goosegrass (*Eleusine indica (L) Gaertn*) in Malaysia*, 56 PEST MGMT. SCI. 336, 336 (2000).

166. *See generally* BILL CURRAN ET AL., BIOLOGY AND MANAGEMENT OF COMMON LAMBSQUARTERS 3 (Glyphosate, Weeds, and Crops Ser. No. 11, 2007), *available at* https://www.extension.purdue.edu/extmedia/BP/GWC-11.pdf.

glyphosate resistance[167] is particularly dispiriting. Glyphosate had emerged as a solution to older herbicides affected by the EPA's acceptance of the voluntary cancellation and amendments to terminate the use of organic arsenicals, including the pesticides monosodium methanearsonate (MSMA), disodium methanearsonate (DSMA), calcium acid methanearsonate (CAMA), and cacodylic acid and its sodium salt, under Section 6(f)(1) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).[168] As resistance to glyphosate proliferates in geographic space and across biological taxa, we may soon reach—if we have not already surpassed—the point of "peak glyphosate," the moment where we can foresee the decline in effectiveness and the eventual commercial extinction of this herbicide.[169]

Pending glyphosate's gradual but inevitable slide into biologically compelled desuetude, we must remember that pesticides and herbicides do not go gentle into that good night.[170] Despite its notorious reputation as an endocrine disruptor and an emasculator of frogs,[171] the much older and more environmentally treacherous atrazine remains the leading

167. *See* Grace A. Hite et al., *Differential Response of a Common Lambsquarters (*Chenopodium album*) Collection to Glyphosate*, 56 WEED SCI. 203, 204 (2008); Christopher L. Schuster et al., *Response of Common Lambsquarters (*Chenopodium album*) to Glyphosate as Affected by Growth Stage*, 55 WEED SCI. 147, 147 (2007); Andrew M. Westhoven et al., *Characterization of Selected Common Lambsquarters (*Chenopodium album*) Biotypes with Tolerance to Glyphosate*, 56 WEED SCI. 685, 685 (2008).

168. 7 U.S.C. § 136d(f)(1) (2012); *see* Organic Arsenicals: Product Cancellation Order and Amendments to Terminate Uses, 74 Fed. Reg. 50,187 (Sept. 30, 2009), *amended by* Organic Arsenicals; Amendments to Terminate Uses; Amendments to Existing Stocks Provisions, 78 Fed. Reg. 18,590 (Mar. 27, 2013). Notably, the EPA exempted the use of MSMA on cotton.

169. In adopting the phrase "peak glyphosate," I invoke the concept of "peak oil," based on the notion that humanity at some point either has crossed or will cross the point of maximum production of a finite, declining fossil resource. *See* M. KING HUBBERT, NUCLEAR ENERGY AND THE FOSSIL FUELS 22 (1956), *available at* http://www.hubbertpeak.com/hubbert/1956/1956.pdf. *See generally* Adam R. Brandt, *Testing Hubbert*, 35 ENERGY POL'Y 3074, 3074–75 (2007).

170. Dylan Thomas, *Do Not Go Gentle into That Good Night*, *in* THE POEMS OF DYLAN THOMAS 239 (Daniel Jones ed., 2003).

171. *See* Tyrone Hayes et al., *Atrazine-Induced Hermaphroditism at 0.1 ppb in American Leopard Frogs (*Rana pipiens*): Laboratory and Field Evidence*, 111 ENVTL. HEALTH PERSPS. 568, 571, 574–75 (2003); Tyrone B. Hayes et al., *Atrazine Induces Complete Feminization and Chemical Castration in Male African Clawed Frogs (*Xenopus laevis*)*, 107 PROC. NAT'L ACAD. SCIS. U.S.A. 4612, 4614–16 (2010); Janet Koprivnikar, Mark R. Forbes & Robert L. Baker, *Contaminant Effects on Host-Parasite Interactions: Atrazine, Frogs, and Trematodes*, 26 ENVTL. TOXICOL. & CHEM. 2166, 2169–70 (2007); Kaori Mizota & Hiroshi Ueda, *Endocrine Disrupting Chemical Atrazine Causes Degranulation through $G_{q/11}$ Protein-Coupled Neurosteroid Receptor in Mast Cells*, 90 TOXICOL. SCIS. 362, 367 (2005).

herbicide in the United States.[172] Glyphosate surely will rage, rage against the dying of its light.[173] Whatever its other implications for intellectual property law and the economics of American agriculture,[174] the impending expiration of Monsanto's patent on the Roundup Ready® trait in soybeans will almost certainly expand the use of glyphosate and the rate at which non-crop plants evolve resistance to that herbicide. After the expiration of that patent in 2015, after all, farmers can save first-generation Roundup Ready® soybean seeds with impunity and sell them for any nonreproductive or reproductive purpose.[175]

Meanwhile, superweed resistance to glyphosate has spurred the development of crops engineered to tolerate another organophosphorus compound with broad-spectrum herbicidal qualities, glufosinate.[176] Bayer CropScience, a leading rival to Monsanto, has incorporated glufosinate resistance into soybeans, cotton, corn, and canola[177] and intends to expand production of the herbicide itself.[178] Atrazine yesterday, glyphosate today, glufosinate tomorrow.

For all of these problems, there is no simple solution.[179] One by one, broad-spectrum herbicides crippled by the emergence of resistance in a wide variety of superweed species may face possible cancellation, or at least a change in their classification, under Section 6(b) of FIFRA.[180]

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172. *See* Frank Ackerman, *The Economics of Atrazine*, 13 INT'L J. OCCUP. & ENVTL. HEALTH 441, 441 (2007), *available at* http://www.ase.tufts.edu/gdae/Pubs/rp/EconAtrazine.pdf; *Atrazine: Chemical Summary*, ENVTL. PROTECTION AGENCY, http://www.epa.gov/teach/chem_summ/Atrazine_summary.pdf (last updated Apr. 24, 2007).

173. Thomas, *supra* note 170, at 239.

174. For further insights into this issue, see Benjamin M. Cole, Brent J. Horton & Ryan Vacca, *Food for Thought: Genetically Modified Seeds as De Facto Standard-Essential Patents*, 85 U. COLO. L. REV. 313 (2014); Lim, *supra* note 14, at 206–14.

175. *Soybeans.com Provides Information about Monsanto's Original Roundup Ready Soybean Patent Expiration*, MONSANTO (Oct. 22, 2013), http://news.monsanto.com/press-release/corporate/soybeanscom-provides-information-about-monsantos-original-roundup-ready-soyb.

176. *See generally* U.S. ENVTL. PROT. AGENCY, GLUFOSINATE SUMMARY DOCUMENT REGISTRATION REVIEW: INITIAL DOCKET MARCH 2008 (Docket No. EPA-HQ-OPP-2008-0190).

177. *See All Crops*, BAYER CROPSCIENCE, http://www.bayercropscience.us/products/traits/libertylink/crops (last updated Nov. 19, 2013).

178. *See* News Release, Bayer CropScience, Bayer CropScience Announces Intention to Construct a State-of-the-Art Facility for Glufosinate-Ammonium Herbicide (May 15, 2013), *available at* http://www.presse.bayer.de/BayNews/Baynews.nsf/BDD2EC5315BF0B13C1257B6C0049A41B/$file/2013-0284e.pdf.

179. *See generally* Rebecca M. Bratspies, *Some Thoughts on the American Approach to Regulating Genetically Modified Organisms*, 16 KAN. J.L. & PUB. POL'Y 393, 405–14 (2007).

180. 7 U.S.C. § 136d(b) (2012).

Contemporary agriculture has ascended the treadmill of the gods, biotechnology as the great conveyor belt of good and evil. What is certain is that the terms by which farmers must pay for access to biotechnology and, critically, must refrain from saving herbicide-resistant seed, has no impact on the truly grand questions of environmental integrity. Seed saving and agrarian tradition offer little succor in a world where food security remains elusive[181] and the ghost of Malthus still stalks.[182] For the harvest is past, the summer is ended, and seed is not saved.

TABLE: SEED-SAVING AND REVERSE-ENGINEERING TECHNIQUES

TECHNIQUE	SOURCE(S) OF LAW	ILLUSTRATIVE CASES
Planting for nonreproductive use	Express and implied licenses accompanying seed sales (seed-wrap licensing)	All agriculture
Bin run	Seed-wrap licensing; antitrust (alleged tying arrangement); *cf.* post-1994 PVPA	*McFarling I* and *II*; *Trantham* (2001–04); *Scruggs* (2006); *David* (2008)
Brown-bag sales	Pre-1994 PVPA; UPOV; U.N. Undertaking on Agriculture ("farmers' rights")	*Asgrow v. Winterboer* (1995)
Chasing selfs	Trade secret	*Pioneer v. Holden* (1994)
"Sieve of phytotoxicity"	Patent	*Bowman v. Monsanto* (2013)

181. *See, e.g.*, Paul Gepts, *A Comparison between Crop Domestication Classical Plant Breeding and Genetic Engineering*, 42 CROP SCI. 1780 (2002); Jonathan Knight, *A Dying Breed*, 421 NATURE 568, 570 (2003); Susan McCouch, *Diversifying Selection in Plant Breeding*, 2 PLOS BIOL. 1507, 1510–11 (2004); *cf.* Ann Marie Thro & Paul Zankowski, *Classical Plant Breeding Is the Route to Food Security*, 422 NATURE 559 (2003).

182. *See generally* THOMAS MALTHUS, AN ESSAY ON THE PRINCIPLE OF POPULATION 15–22 (Geoffrey Gilbert ed., Oxford World's Classics 1999) (1798); Keith Aoki, *Malthus, Mendel, and Monsanto, Intellectual Property and the Law and Politics of Global Food Supply: An Introduction*, 19 J. ENVTL. L. & LITIG. 397, 399–400 (2004).