

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

INARI AGRICULTURE, INC.,
Petitioner,

v.

PIONEER HI-BRED INTERNATIONAL, INC.,
Patent Owner.

Case No. PGR2024-00020
Patent No. 11,666,020

DECLARATION OF RAYMOND D. RILEY, PH.D.

Inari Exhibit 1003 Inari v. Pioneer
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I, Raymond D. Riley, Ph.D., hereby declare under penalty of perjury:

I. INTRODUCTION

1. My name is Raymond D. Riley, and I have been retained by counsel for Petitioner Inari Agriculture, Inc. (“Inari” or “Petitioner”) as an expert witness to provide analysis regarding U.S. Patent No. 11,666,020 (the “’020 Patent”), which I understand has been designated as EX1001. Specifically, I have been asked to consider the validity of claims 1-20 of the ’020 Patent (the “Challenged Claims”) in view of prior art, the non-obviousness and utility requirements, and the understanding of a person of ordinary skill in the art at the time of the invention as it relates to the ’020 Patent. I have personal knowledge of the facts and opinions set forth in this declaration and believe them to be true. If called upon to do so, I would testify competently thereto.

2. I am being compensated for my time at my standard consulting rate. I am also being reimbursed for expenses that I incur during the course of this work. My compensation is not contingent upon the results of my study, the substance of my expert opinions, or the outcome of any proceeding involving the challenged claims. I have no financial interest in the outcome of this matter or on the pending litigation between Petitioner and Patent Owner. My analysis here is based on my years of education, research, and experience, as well as my investigation and study of relevant materials, including those cited herein.

3. I may rely upon these materials, my knowledge and experience, and/or additional materials to rebut arguments raised by the Patent Owner. Further, I may also consider additional documents and information in forming any necessary opinions, including documents that may not yet have been provided to me.

4. My analysis of the materials produced in this proceeding is ongoing and I will continue to review any new material as it is provided. This declaration represents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my expert opinions stated herein based on new information and on my continuing analysis of the materials already provided.

II. BACKGROUND AND QUALIFICATIONS

5. I am an expert in the field of plant breeding and genetics. I have studied, taught, practiced, and researched in this field for over 45 years. I have summarized in this section my educational background, work experience, and other relevant qualifications. My curriculum vitae, which I understand has been designated EX1004, describes my background and experience.

A. Academic Training

6. I earned my Bachelor of Science degree in Soil & Crop Science with a second major in Agribusiness Management from the University of Wisconsin – Platteville in 1977. I earned a Master of Science degree in Plant Breeding and

Genetics from the University of Nebraska in 1980. In 1981, I earned a Doctor of Philosophy degree, in Plant Breeding and Genetics with a minor in Organization Behavior and Performance, also from the University of Nebraska. My dissertation entitled “Heritability of Mature Plant Traits in Sand Bluestem,” was directed to studies on inheritance of certain agronomically important traits in sand bluestem, a perennial tall-grass native to the Great Plains.

B. Selected Professional Experience

7. After completing my Doctor of Philosophy degree, I worked at Pioneer Hi-Bred International, Inc. (“PHI”), beginning in 1981. From 1981 to 1990, I was a research program manager and corn breeder. I was responsible for management of an integrated research program directed toward development of commercial corn. I was also responsible for commercial research interactions to effectively focus research efforts, communicate research results and enhance commercial success.

8. In that role, I developed several inbred and hybrids of commercial and germplasm significance. I was the co-inventor of a patent (U.S. Patent No. 5,491,295) for corn hybrid 3394, which at one point was the largest selling corn hybrid. PHI has stated that hybrid 3394 “became so dominant by the mid-90s that, by itself, it outsold the entire hybrid lineups of all competitor seed companies.”

EX1019, “A Brief History of Corn – From Domestication to 1995,” PHI (Dec. 19, 2022), <https://www.pioneer.com/us/agronomy/domestication-of-corn.html>.

9. From 1991 to 2000, I was a research director for PHI and, after DuPont’s acquisition of PHI in October 1999, for DuPont. I was initially the research commercial liaison and director of corn breeding and product development efforts for Africa/Middle East/Pacific Rim. Later, I was responsible for North Central Corn-Belt corn product development. Later still, I was responsible for product characterization and commercialization (PCC) of corn for South America, Africa, Middle East, Asia and China. Each of these roles involved, among other things, working with or directing the activities of teams breeding and/or developing new inbred and hybrid corn varieties.

10. I then moved to Syngenta Seeds, where I worked from 2000 to 2015. From 2000 to 2003, I was Syngenta’s Global Corn Seed Production Head based in Toulouse, France. From 2003 to 2004, I was the Global Head of Field Crops Research and Development. In these roles, I again worked directly with and/or directed the activities of teams breeding varieties of corn and other crops.

11. From 2004 to 2010, I was the head of NAFTA corn and soybean seeds research and development, based in Minnetonka, Minnesota. In that role, I developed a high-performance corn and soybean research and development team

that has repositioned Syngenta's corn and soybean product offerings to be among the best in the industry.

12. From 2010 to 2011, I was the global head, corn seeds research and development. In that role, I represented seeds research and development in the establishment of a global corn seeds strategy and managed Syngenta's global corn breeding and trait development portfolio.

13. From 2011 to 2014, I was the global head of germplasm technology. In that role, I led the establishment of a global cross crop plant breeding technical excellence program for application of breeding, statistical and emerging molecular biology technologies. I also established the "Syngenta Plant Breeding Academy" to enable ongoing state of the art skill development and networking of Syngenta scientists and our key collaborators.

14. From 2013 to 2014, I was the head of Traits Research, leading traits research teams responsible for GM (genetically modified) and non-GM traits for insect and disease resistance, yield, and stress tolerance. From 2014 to 2015, I was the Head of Computational Biology. In that role I established an integrated Computational Biology team to support Syngenta's research and development efforts spanning breeding, trait development (GM and Native) and chemistry.

15. From 2015 to 2018, I was the Senior Vice President of Product Development at Indigo Ag Inc. At Indigo, I led teams and projects focused on product development of microbiome-based crop production enhancing products.

16. Since 2018, I have worked as a consultant to a range of Ag Tech startups in areas spanning crop genetics, AI assisted breeding, gene editing, seed business strategy, biotech, microbial seed treatments, soil carbon sequestration and environmentally sustainable practices. Beginning in 2020 to present, I have also served as a member of the global Loam Bio Management Team at Loam Bio LLC, with a focus on research and development. Loam Bio develops programs to remove carbon from the atmosphere and store it in the soil, improving agricultural productivity.

17. As a leader of corn breeding teams and programs, it was my responsibility to ensure that investments in this area were delivering utility and supporting the commercial success of the company I was employed with, as well as the customers who utilized the developed product.

C. Patents

18. I am the inventor or a co-inventor of a number of patents in corn breeding and related fields including:

- a. US Patent No. 5,159,133 (EX1092) entitled “Inbred Corn Line PHV37;”

- b. US Patent No. 5,491,295 (EX1080) entitled “Hybrid Corn Plant and Seed;”
- c. US Patent No. 10,624,351 entitled “Modulated Nutritional Quality Traits in Seeds” (related patents: US 11,178,876; US 11,766,045);
- d. US Patent No. 10,640,783 entitled “Endophyte Compositions and Methods of Improvement of Plant Traits” (related patents: US 11,516,989); and
- e. US Patent No. 10,645,938 entitled “Endophyte Composition and the Methods for Improvement of Plant Traits.”

III. LEVEL OF ORDINARY SKILL IN THE ART

19. In rendering the opinions set forth in this declaration, I was asked to consider the patent claims and the prior art through the eyes of one of ordinary skill at the time of the claimed invention, which I understand to be July 2, 2021—the filing date of the application that issued as the ’020 Patent, and the earliest priority date to which the claims of the issued patent are entitled. I understand that the factors considered in determining the ordinary level of skill in a field of art include the level of education and experience of persons working in the field; the types of problems encountered in the field; the teachings of the prior art, and the sophistication of the technology at the time of the claimed invention. I understand that one of ordinary skill is not a specific real individual, but rather is a

hypothetical individual having the qualities reflected by the factors above. I understand that one of ordinary skill would also have knowledge from the teachings of the prior art, including the art cited below.

20. Taking these factors into consideration, on or before July 2, 2021, one of ordinary skill relating to the technology of the '020 Patent would have had a high level of skill. In particular, a POSA would have had a doctoral degree in plant breeding or a related field, at least five years of experience with corn breeding, and additional experience interfacing with laboratory-side personnel (including a computational biologist along with genetics specialists) as well as field-side personnel. Alternatively, additional experience could take the place of an advanced degree.

21. It has long been expected that substantial academic preparation was important to work as a corn breeder. For example, in a widely cited 1991 text entitled *Principles of Cultivar Development*, Walter Fehr described the academic experience expected for a plant breeder in terms that also applied in 2021:

To be capable of planning and conducting an effective plant breeding research program, a person needs an appropriate undergraduate and graduate education. The education includes a mixture of formal courses, independent research experience in working with an active research program, and informal interaction with students and faculty. Academic courses include plant breeding and those disciplines that contribute to cultivar development. Independent research gives

experience in planning, conducting, and interpreting experiments. Participation in an active research program is a means of obtaining practical experience with breeding techniques and methods. Informal interaction with students and faculty provides the opportunity to evaluate new ideas and concepts.

EX1016, Fehr, 8 (internal citation omitted). Indeed, the amount of education and experience required to run a successful breeding program has only increased over the years, especially as genetics, genomics, data science, and computational techniques have become increasingly important to breeding programs. In addition, an important aspect of the breeder's role is the ability to use breeding skills to create value for the company and enable business and customer (*i.e.*, farmer) success.

22. Before July 2, 2021, my level of skill in the art was at least that of one of ordinary skill. I am very familiar with the experience and knowledge of a POSA as of 2021. I held comparable positions to a POSA in the 1980s-90s. More recently, I have held positions in which I directed and/or worked with people who would be considered POSAs, including in leadership roles at PHI and Syngenta and in consulting roles. I am qualified to provide opinions concerning what one of ordinary skill would have known and understood at that time, and my analysis and conclusions herein are from the perspective of one of ordinary skill as of that date.

IV. MATERIALS CONSIDERED AND RELIED UPON

23. In reaching the conclusions described in this declaration, I have relied on the '020 Patent, the prior art, and other documents and materials cited herein. For ease of reference, the full list of documents that I have considered is included in **Appendix A**.

24. These materials comprise patents, related documents, and printed publications. Each of these materials is a type of document that experts in my field would have reasonably relied upon when forming their opinions.

25. I have also relied on my education, training, research, knowledge, and personal and professional experience in the relevant technologies and systems that were already in use prior to, and within the timeframe of the earliest priority date of the claimed subject matter in the '020 Patent, which is July 2, 2021.

V. LEGAL STANDARDS

26. I am not a lawyer and do not provide any legal opinions, but I have been advised that certain legal standards are to be applied by technical experts in forming opinions regarding meaning and validity of patent claims. I have applied the legal standards described below, which were provided to me by counsel for Petitioner.

A. Obviousness

27. I have been informed that a claim may be unpatentable under 35 U.S.C. § 103(a) if the subject matter described by the claim as a whole would have been obvious in view of a prior art reference or in view of a combination of references at the time the alleged invention was made. I have been informed that obviousness is determined from the perspective of a hypothetical person of ordinary skill in the art (“POSA” or “person of ordinary skill”) and that the challenged claims of the patent should be read from the point of view of such a person at the time the alleged invention was made. I have been informed that a hypothetical person of ordinary skill is assumed to know and to have all relevant prior art in the field of endeavor covered by the patent in suit, and would thus have been familiar with each of the references cited herein, as well as the background knowledge in the art, and the full range of teachings they contain.

28. I have been informed that there are two criteria for determining whether prior art is analogous and thus can be considered prior art: (1) whether the art is from the same field of endeavor, regardless of the problem addressed, and (2) if the reference is not within the field of the patentee’s endeavor, whether the reference still is reasonably pertinent to the particular problem with which the patentee is involved. I have also been informed that the field of endeavor of a patent is not limited to the specific point of novelty, the narrowest possible

conception of the field, or the particular focus within a given field. I have also been informed that a reference is reasonably pertinent if, even though it may be in a different field from that of the patentee's endeavor, it is one which, because of the matter with which it deals, logically would have commended itself to a patentee's attention in considering the problem.

29. I have also been informed that an analysis of whether an alleged invention would have been obvious should be considered in light of the scope and content of the prior art, the differences (if any) between the prior art and the alleged invention, and the level of ordinary skill in the pertinent art involved. I have been informed as well that a prior art reference should be viewed as a whole.

30. I have also been informed that in considering whether an invention for a claimed combination would have been obvious, I may assess whether there are apparent reasons to combine known elements in the prior art in the manner claimed in view of interrelated teachings of multiple prior art references, the effects of demands known to the design community or present in the market place, and/or the background knowledge possessed by a person of ordinary skill. I have been informed that other principles may be relied on in evaluating whether an alleged invention would have been obvious, and that these principles include the following:

- A combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results;
- When a device or technology is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or in a different one, so that if a person of ordinary skill can implement a predictable variation, the variation is likely obvious;
- If a technique has been used to improve one device, and a person of ordinary skill would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill;
- An explicit or implicit teaching, suggestion, or motivation to combine two prior art references to form the claimed combination may demonstrate obviousness, but proof of obviousness does not depend on or require showing an explicit teaching, suggestion, or motivation to combine;
- Market demand, rather than scientific literature, can drive design trends and may show obviousness;

- In determining whether the subject matter of a patent claim would have been obvious, neither the particular motivation nor the avowed purpose of the named inventor controls;
- One of the ways in which a patent's subject can be proved obvious is by noting that there existed at the time of invention a known problem for which there was an obvious solution encompassed by the patent's claims;
- Any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed;
- "Common sense" teaches that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle;
- A person of ordinary skill is also a person of ordinary creativity, and is not an automaton;
- A patent claim can be proved obvious by showing that the claimed combination of elements was "obvious to try," particularly when there is a design need or market pressure to solve a problem and there are a finite

number of identified, predictable solutions such that a person of ordinary skill would have had good reason to pursue the known options within his or her technical grasp; and

- One should be cautious of using hindsight in evaluating whether an alleged invention would have been obvious.

31. I have further been informed that, in making a determination as to whether or not the alleged invention would have been obvious to a person of ordinary skill, the Board may consider certain objective factors if they are present, such as: commercial success of products practicing the alleged invention; long-felt but unsolved need; teaching away; unexpected results; copying; and praise by others in the field. These factors are generally referred to as “secondary considerations” or “objective indicia” of nonobviousness. I have been informed, however, that for such objective evidence to be relevant to the obviousness of a claim, there must be a causal relationship (called a “nexus”) between the claim and the evidence and that this nexus must be based on what is claimed and novel in the claim rather than something in the prior art. I also have been informed that even when they are present, secondary considerations may be unable to overcome primary evidence of obviousness (e.g., motivation to combine with predictable results) that is sufficiently strong.

32. I have been asked to consider the patentability of claims 1-20 (the “Challenged Claims”) of the ’020 Patent that are challenged in the Petition.

33. I have been informed that for PGRs, unpatentability must be shown under a preponderance of the evidence. I have been informed that to establish something by a preponderance of the evidence one needs to prove it is more likely true than not true. I have concluded that the Challenged Claims are unpatentable under 35 U.S.C. § 103 (for obviousness) as described below, under both the preponderance of the evidence standard as well as the higher standard of clear and convincing evidence. The same is true for my conclusion, as also described below, that the Challenged Claims are unpatentable under 35 U.S.C. § 101 for lack of specific utility.

B. Claim Construction

34. I have been informed that patent claims are construed from the viewpoint of a person of ordinary skill at the time of the alleged invention. I have been informed that patent claims generally should be interpreted consistent with their plain and ordinary meaning as understood by a person of ordinary skill in the relevant time period (i.e., at the time of the purported invention, or the so called “effective filing date” of the patent application), after reviewing the patent claim language, the specification and the prosecution history (i.e., the intrinsic record).

C. Utility

35. I have been informed that the statutory basis for the utility requirement is found in 35 U.S.C. § 101, which provides:

Whoever invents or discovers any new and ***useful*** process, machine, manufacture, or composition of matter, or any new and ***useful*** improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title. (emphasis added)

36. I have been informed by counsel that the Supreme Court has interpreted the statute to mean that “one may patent only that which is ‘useful.’” *Brenner v. Manson*, 383 U.S. 519, 528-29 (1966). Specifically, the utility must be (i) specific, practical, and substantial. *Grunenthal GMBH v. Alkem Lab'ys Ltd.*, 919 F.3d 1333, 1345 (Fed. Cir. 2019). The utility must be “substantial” meaning a utility that “provides a specific benefit in currently available form.” *Ex parte Fisher*, 72 U.S.P.Q.2d 1020, 1025 (B.P.A.I. 2004).

37. Counsel has informed me that the courts have held that “inventions do not meet the utility requirement if they are ‘objects upon which scientific research could be performed with no assurance that anything useful will be discovered in the end.’” *In re '318 Pat. Infringement Litig.*, 583 F.3d 1317, 1324 (Fed. Cir. 2009). For example, an application for a proposed drug to treat dementia was held unpatentable where the applicant’s argument for utility was based only on

“analytic reasoning” about the drug without any results of testing in animals or people. *Id.*, 1326-28.

38. Further, I also understand from counsel that the Supreme Court has cautioned that “a patent is not a hunting license,” meaning that “[u]nless and until a process is refined and developed to [the] point—where specific benefit exists in currently available form—there is insufficient justification for permitting an applicant to engross what may prove to be a broad field” by obtaining a patent. *Brenner*, 383 U.S. at 534-36. Counsel has informed me that, for example, in a case involving expressed sequence tags (“ESTs”) in maize, the courts held that claims to specific ESTs were not patentable where the applicant’s only alleged utility were general uses of ESTs and the claimed ESTs were not tied to any specific utility, nor differentiate the claimed ESTs from any other ESTs. *In re Fisher*, 421 F.3d 1365, 1365-68 (Fed. Cir. 2005). Because the applicant “only disclosed general uses for its claimed ESTs, not specific ones that satisfy §101,” the claims were not patentable. *Id.* at 1374.

39. Finally, I understand that utility is determined as of the application filing date. *In re Brana*, 51 F.3d 1560, 1567 n.19 (Fed. Cir. 1995).

VI. DESCRIPTION OF THE RELEVANT FIELD AND TIMEFRAME

40. I understand that the ’020 Patent issued from U.S. Patent Application No. 17/366,059, filed on July 2, 2021. I have been instructed by counsel to assume

the relevant timeframe for my analysis in this declaration is on or before July 2, 2021.

41. Based on my review of this material, I believe that the relevant field for the purposes of the '020 Patent is, as identified above, corn breeding. For example, the patent discusses the “continuing goal of maize breeders...to develop stable, high yielding maize varieties and hybrids that are agronomically sound with maximal yield over one or more different conditions and environments.” EX1001, 1:23-26.

VII. OVERVIEW OF THE '020 PATENT

A. Subject Matter of the '020 Patent

42. The '020 Patent is directed to an inbred corn variety designated 1PFHC43, which originated from a cross between inbred line PH1VNA and inbred line PH1D84. EX1001, 38:26-28. The '020 Patent states that “[f]rom this cross, ears were selected based on genetic analysis predicting disease, insect, and agronomic phenotypic performance. Inbred 1PFHC43 was developed by producing a doubled haploid from the F1 plants, selfing and using pedigree selection amongst the D1 lines, and selfing and bulking from the subsequent generations.” EX1001, 38:28-34. These techniques were well known to POSAs. For example, U.S. Patent Nos. 9,848,573 (EX1036); 10,681,888 (EX1006); and 10,165,747 (EX1038), and many other PHI patents published before the priority

date, included the same disclosure—including, in the case of the patents listed here, the use of inbred line PH1D84 as one of the parents. *See* EX1036, 18:59-64; EX1006, 38:55-61; and EX1038, 42:64-43:3; *see also* EX1020, Geiger, “Doubled Haploids in Hybrid Maize Breeding,” *Maydica* 54:485-99, 486 (2009) (“After artificial chromosome doubling the successfully treated seedlings are selfed leading to completely homozygous and homogeneous progenies (DH lines).”); EX1021, Weber, “Today’s Use of Haploids in Corn Plant Breeding” in *Advances in Agronomy*, Volume 123 (2014) (“Haploid plants with fertile sectors are self-pollinated if possible.”).

43. Aside from the variety designation itself, the “Abstract,” “Background,” and “Summary” sections are essentially identical to those in multiple prior art patents such as Longenberger (EX1006) and disclose information that would have already been well known to POSAs prior to the ’020 Patent’s July 2, 2021 filing date. I understand that EX1093 is a comparison between the text of the ’020 Patent and the text of the earlier Longenberger patent, which are substantially identical.

44. For example, the Background sections of both Longenberger and the ’020 conclude by identifying a “continuing goal of maize breeders...to develop stable, high yielding maize varieties and hybrids that are agronomically sound with

maximal yield over one or more different conditions and environments.” EX1001, 1:23-26; Longenberger, 1:23-26.

45. The “Detailed Description” section likewise closely tracks multiple prior art patents such as Longenberger. Similarities include:

- Similar “Definitions” sections (compare EX1001, 4:46-14:67 with Longenberger, 4:46-15:2)
- Identical “Phenotypic Characteristics” sections other than the designations themselves (i.e., 1PFHC43 versus PH47K2) (compare EX1001, 15:1-15 with Longenberger, 15:3-17)
- Essentially identical “Genotypic Characteristics” sections other than the designations themselves (compare EX1001, 15:16-17:38 with Longenberger, 15:18-17:45)
- Essentially identical sections on:
 - “Comparing ... to Other Inbreds” (compare EX1001, 17:40-18:12 with Longenberger, 17:46-18:17);
 - “Development of Maize Hybrids” (compare EX1001, 18:14-19:8 with Longenberger, 18:19-19:12);
 - “Combining Ability” (compare EX1001, 19:10-42 with Longenberger, 19:13-44);

- “Introduction of a New Trait or Locus” (compare EX1001, 19:44-21:46 with Longenberger, 19:45-21:55);
- “Male Sterility and Hybrid Seed Production” (compare EX1001, 21:47-23:24 with Longenberger, 21:56-23:39);
- “Develop[ing] Another Maize Plant” (compare EX1001, 31:55-32:20 with Longenberger, 32:38-33:2); and
- “Industrial Applicability” (compare EX1001, 36:49-37:26 with Longenberger, 37:21-65).

46. While the data in the ’020 Patent’s “Table 1” (“Variety Description Information”) varies slightly from that in the prior art tables, the differences are insubstantial, as discussed in further detail in Section IX.A below. There is no basis in the ’020 Patent or other reason to think that the traits would have fallen outside the range of expected outcomes from the breeding cross this line was developed from. *See, e.g.*, below, paragraphs 65-75 (comparing traits to prior art including disclosed parent and siblings); paragraphs 76-82 (discussing statistical analysis).

47. Moreover, the fields themselves (e.g., “branch angle” and “tassel length”) are taken verbatim from portions of a U.S. Department of Agriculture (USDA) form used in connection with applications for certificates under the Plant Variety Protection Act (PVPA). EX1008, 6-8; EX1009, 5-11; EX1010, 8-11. The

characteristics in question facilitate assessing distinctiveness for purposes of the PVP—not utility or non-obviousness for purposes of the Patent Act. In order to identify a distinctive variety in the days before genotyping was available, the practice developed of identifying a new variety using the set of characteristics identified by the USDA in the PVPA form.

VIII. TECHNICAL BACKGROUND AND STATE OF THE ART

48. By 2021, the art of corn breeding was well developed. As one of the world’s most important staple crops, Maize (*Zea mays*; commonly known as corn) has been the subject of well-developed breeding and selection techniques dating back roughly nine thousand years.

49. Modern cross techniques date back to 1867, when plant breeders began directing pollen from one maize plant to another. In 1878–1881, crossing maize varieties to grow the production of commercial cultivars was proposed. EX1012, Lee, “Modern Maize Breeding,” in Bennetzen (ed.), *Maize Handbook* (2009), 140-42. Maize genes important for commercially relevant traits also began to be discovered. *Id.* A revolutionary step in maize breeding began with the demonstration of ‘hybrid vigor’ or heterosis in crossed inbred lines in 1909. *See, e.g.,* EX1013, Byerlee, “The globalization of hybrid maize, 1921–70,” *Journal of Global History* (2020), 15:1, 101-122 (“The exploitation of hybrid vigour was unique at the time to maize, which, unlike most other major crops, is an open-

pollinating crop with separate male and female flowers. This characteristic greatly facilitated controlled pollination needed for in-breeding parent lines over several cycles, and then crossing the inbreds to produce hybrids. With the right combination of inbred parents, the yield gain was as much as 50% above the yield of the parental OPVs, but more commonly averaged 15–20%.”); EX1015, Andorf, “Technological advances in maize breeding: past, present and future,” *Theoretical and Applied Genetics*, 132:817–849 (2019). In 1933, the first hybrid maize created by crossing inbred lines was introduced, and maize breeding started entering the “hybrid era.” *See* EX1013, Byerlee, 101; EX1012, Lee, 149.

50. Employment of modern genetics and molecular biology techniques in maize breeding started in the 1970s–1980s with the first regenerated plant from a cell culture and sequencing the first maize genes. EX1015, Andorf, 820-21. These modern techniques aided the identification of genes conferring desirable traits such as disease and/or insect resistance. Transgenic maize varieties began to emerge in the late 1990s, and transgenic hybrids that could confer insect resistance, herbicide tolerance, high lysine content, and drought-resistance were commercialized. EX1011, Lundmark, “Genetically Modified Maize,” *BioScience*, 57, 996 (2007).

51. Principles and methods of maize breeding and cultivar development to produce maize varieties with desirable traits have been described in various frequently cited textbooks and publications including, e.g., Fehr et al., *Principles of*

Cultivar Development, (1987) (EX1016); Wych et al., Production of Hybrid Seed, Corn and Corn Improvement, Chapter 9 (1988) (EX1017); Lee et al., Handbook of Maize, Modern Maize Breeding (2009) (EX1012); and Andorf et al., Theor Appl Genet. 132(3):817-849 (2019) (EX1015). Such principles and techniques are also well known and routinely practiced by those skilled in the art of maize breeding.

52. By selecting appropriate varieties for crosses, it became routine over time to use cross breeding to adjust phenotypes successively to generate the changes and improvements in desired characteristics.

53. Fehr's text sets forth some of the reasons why inbred lines are desirable:

One important purpose of inbreeding is the development of genotypes that can be maintained through multiple generations of seed production. Self-pollinated cultivars are reproduced for many generations without changes in their genetic composition. Reliable production of inbred commercial hybrid seed of a species is dependent on the availability of inbred parents whose genotype can be maintained.

Inbreeding has been used to reduce the frequency of deleterious recessive alleles in genotypes that serve as parents of a synthetic or a vegetatively propagated cultivar. One selfed generation [in other words, pollinating a plant by itself] may permit the expression and subsequent elimination of deleterious alleles without excessive inbreeding depression occurring in lines selected for use as parents for population development.

Inbreeding increases the genetic variability among individuals in a population. Greater genetic variability among inbred progeny can increase the effectiveness of selection and the amount of genetic improvement in a breeding program.

EX1016, 106-107.

IX. GROUND 1-3: CLAIMS 1-20 ARE UNPATENTABLE AS OBVIOUS OVER THE PRIOR ART

54. In my opinion, Claims 1-20 are unpatentable as obvious over the prior art as of July 2, 2021. I describe in detail the basis for my opinion in this Section IX. At a high level, I reach this opinion because the variation from the original parent performance is very much within the range of what would be expected to be achieved by breeding a new line from the parental line.

55. As the '020 Patent's Variety Description Information (Table 1) confirms, the inbred 1PFHC43 variety covered by claim 1 has characteristics very similar to those in multiple other inbred varieties disclosed in the prior art. As discussed further below, to the extent there are differences, nothing in the specification suggests any reason why such differences were significant and/or unexpected as compared to prior art varieties.

56. Moreover, claims 2-20 recite standard applications for inbred corn variety (e.g., crossing the particular inbred variety with a different variety to create

an F1 hybrid). Such applications would have been obvious for any known or obvious inbred corn line as of July 2, 2021.

A. Graham Factor Analysis Relevant to Grounds 1-3

57. I will now address: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) any secondary considerations identified by the Patent Owner. I understand from counsel that these are known as the “Graham” factors and form the basis for assessing whether a claimed invention would have been obvious at the time of the patent application in question (here, July 2, 2021).

1. Scope and Content of the Prior Art

58. I discussed the general state of the art in Section VIII above.

59. In addition, Smalley (EX1005), Smalley’s related PVP certificate (EX1008),¹ Longenberger (EX1006), Longenberger’s related PVP certificate (EX1009),² Hoffbeck (EX1007), and Hoffbeck’s related PVP certificate

¹ I have generally relied on the data presented in Smalley (EX1005), but I note below several instances in which the related PVP certificate (EX1008) provides different information.

² I understand that Longenberger’s related PVP certificate issued in 2023. *See* EX1010, p. 1. Comparing Longenberger (EX1006) to EX1010 shows that the data

(EX1010) all disclose inbred corn lines with characteristics very similar to those of the claimed 1PFHC43 as illustrated in the table below. The table is based on the “Table 1 – Variety Description Information” in each of the ’020 Patent, Smalley, Longenberger, and Hoffbeck.

	’020 Patent (1PFHC43)	Smalley (PH1D84)	Longenberger (PH47K2)	Hoffbeck (PHH5G)
TYPE:				
Grain Texture	Flint-Dent	Flint	Dent	Flint-Dent
MATURITY:				
Comparative Relative Maturity (days)	111	N/D	108	N/D
Emergence to 50% plants in silk (days)	54	N/D (63) ³	51	58
Emergence to 50% plants in silk (heat units)	1325	N/D (1311.0)	1299	1349
Emergence to 50% plants in pollen shed (days)	55	N/D (62)	52	57
Emergence to 50% plants in	1348	N/D (1279.5)	1325	1329

in EX1006 is consistent with that in EX1010. Accordingly, I have relied on the data in EX1006.

³ Maturity information in Smalley refers to days and heat units from *planting*, rather than from *emergence*. EX1005, Table 1. To allow for a comparison, I have substituted the maturity information from the related PVP Certificate. EX1008, 7.

	‘020 Patent (1PFHC43)	Smalley (PH1D84)	Longenberger (PH47K2)	Hoffbeck (PHH5G)
pollen shed (heat units)				
PLANT:				
Plant height (to tassel tip) (cm), mean (SE)	209.3 (9.26)	179.5 ⁴ (1.47)	207 (6.1)	214.5 (14.45)
Ear height (to base of top ear node) (cm), mean (SE)	72 (6)	58.4 ⁵ (1.24)	75.1 (9.31)	72.0 (9.50)
Length of Top Ear Internode (cm), mean (SE)	13.6 (1.43)	14.7 (0.22)	16.7 (1.98)	16.3 (1.99)
Number of Nodes Above Ground, mean (SE)	13.3 (1.1)	N/D	11.9 (1.77)	N/D
Anthocyanin of Brace Roots (1 = absent, 2 = faint, 3 = moderate, 4 = dark)	2	2	2	1
LEAF:				
Width of Ear Node Leaf (cm), mean (SE)	8.1 (0.62)	8.5 (0.10)	9.3 (0.62)	8.6 (0.51)
Length of Ear Node Leaf (cm), mean (SE)	87.2 (2.84)	80.0 (0.54)	83.9 (4.7)	74.4 (4.45)

⁴ The related PVP Certificate reports a mean plant height of 179.6 cm with standard deviation of 7.55 and sample size of 20. EX1008, 7.

⁵ The related PVP Certificate reports a mean ear height of 60.9 cm with a standard deviation of 8.27 and sample size of 20. EX1008, 7.

	‘020 Patent (1PFHC43)	Smalley (PH1D84)	Longenberger (PH47K2)	Hoffbeck (PHH5G)
Number of Leaves Above Top Ear, mean (SE)	6.2 (0.73)	5.8 (0.09)	5.9 (0.85)	7.5 (0.74)
Leaf Angle (degrees) (at anthesis, 2 nd leaf above top ear to the stalk), mean (SE)	29.8 (7.33)	22.9 (0.64)	26.3 (4.44)	25.4 (3.60)
Leaf Color	V. Dark Green	V. Dark Green	V. Dark Green	V. Dark Green
Leaf Sheaf Pubescence (1 = none to 9 = peach-like fuzz)	2	3 ⁶	4	3
TASSEL:				
Number of Primary Lateral Branches, mean (SE)	3 (1.47)	3.1 (0.24)	1.5 (1.24)	1.1 (1.44)
Branch Angle from Central Spike (degrees), mean (SE)	27 (10.77)	32.4 (1.27)	38.9 (18.73)	11.3 (4.43)
Tassel Length (from peduncle node to tassel tip) (cm), mean (SE)	60.3 (3.45)	54.7 (0.60)	56.5 (4.59)	48.7 (3.35)
Peduncle Length (from top leaf node to lower	25.2 (3.17)	25.1 (0.46)	21.3 (3.74)	21.3 (3.28)

⁶ Smalley gives this value as “3.” *See* EX1005, Table 1. However, the related PVP Certificate reports a leaf sheaf pubescence value of 2. EX1008, 7.

	‘020 Patent (1PFHC43)	Smalley (PH1D84)	Longenberger (PH47K2)	Hoffbeck (PHH5G)
branch) (cm), mean (SE)				
Central Spike Length (cm), mean (SE)	30.6 (3.71)	N/D	30.9 (3.26)	N/D
Flag Leaf Length (cm) (from flag leaf collar to tassel tip), mean (SE)	45.3 (3.32)	N/D	36.4 (4.28)	N/D
Pollen Shed (0 = male sterile to 9 = heavy shed)	4	3	7	2
Bar Glumes (1 = absent, 2 = present)	1	1	1	1
Anther Color	Yellow	Pink	Pale Yellow	Pale Yellow
EAR (Unhusked ear):				
Silk Color	Light Red	Light Green	Light Red	Light Green
Fresh Husk Color	Light Green	Med. Green	Light Green	Med. Green
Dry Husk Color	White	White	Buff	Buff
Ear position at dry husk stage (1 = upright, 2 = horizontal, 3 = pedant)	1	1	1	1
Husk Tightness (1 = very loose to 9 = very tight)	6	7	7	6
Husk Extension (at harvest) (1 = short (ears exposed), 2 = medium (< 8 cm), 3 = long (8-10	2	3	2	2

	‘020 Patent (1PFHC43)	Smalley (PH1D84)	Longenberger (PH47K2)	Hoffbeck (PHH5G)
cm), 4 = very long (> 10cm))				
Length of Interior Husk (cm), mean (SE)	21.1 (1.8)	N/D	20.2 (2.84)	N/D
EAR (Husked ear data):				
Shank Length (cm), mean (SE)	6.7 (1.66)	6.4 (0.31)	8.9 (1.79)	6.7 (0.70)
Ear Length (cm), mean (SE)	16.5 (2.29)	13.5 (0.20)	17 (0.87)	16.7 (0.96)
Ear Diameter at mid-point (mm), mean (SE)	43.6 (1.38)	36.3 (0.35)	36.1 (2.26)	42.9 (1.10)
Ear Weight (gm), mean (SE)	149.7 (26.81)	85.7 (3.06)	107.8 (25.95)	142.3 (13.15)
Number of Kernel Rows, mean (SE)	15.6 (0.99)	13.0 (0.24)	14 (1.3)	16.7 (0.98)
Number of Kernels Per Row, mean (SE)	30.9 (6.09)	N/D	25.4 (4.85)	N/D
Kernel Rows (1 = indistinct, 2 = distinct)	2	2	2	2
Row Alignment (1 = straight, 2 = slightly curved, 3 = spiral)	2	1	1	2
Ear Taper (1 = slight cylindrical, 2 = average, 3 = extreme conical)	2	2	1	2
KERNEL (Dried):				
Kernel Length (mm), mean (SE)	11.7 (0.88)	11.2 (0.12)	8.7 (1.27)	11.1 (0.46)
Kernel Width (mm), mean (SE)	8 (0.6)	8.5 (0.11)	7.5 (0.68)	8.0 (0.93)

	‘020 Patent (1PFHC43)	Smalley (PH1D84)	Longenberger (PH47K2)	Hoffbeck (PHH5G)
Kernel Pericarp Color	Clear	N/D	Colorless	N/D
Aleurone Color Pattern	Homozygous	Homozygous	Homozygous	Homozygous
Aleurone Color	Clear	Yellow	Clear	Yellow
Hard Endosperm Color	Yellow	Yellow	Yellow-Orange	Yellow
Weight per 100 Kernels (unsized sample) (gm), mean (SE)	32.5	31.0 (4.24)	24.3	26.7 (1.15)
COB:				
Cob Diameter at mid-point (mm), mean (SE)	27.2 (1.42)	21.1 (0.21)	20.3 (1.37)	23.1 (0.64)
Cob Color	Pink-Orange	White	White	Red

60. Smalley, Longenberger, and Hoffbeck likewise disclose that the disclosed inbred lines provide “source[s] of breeding material that may be used to develop new maize inbred varieties.” EX1005, 28:33-35; EX1006, 32:41-43; EX1007, 30:33-35.

61. Indeed, as discussed further in paragraph 84 below, the PH1D84 variety disclosed in Smalley was used as the parent for numerous other inbred varieties as confirmed by other PHI patents. The varieties disclosed in Longenberger and Hoffbeck have also gone on to be the parents of varieties claimed in other patents. Longenberger is directed to PH47K2, which is identified as a parent in US Patent No. 10,863,705 (“Maize Hybrid X08N769”) (EX1060).

Hoffbeck is directed to PHH5G, which is identified as a parent in US Patent No. 9,596,820, 18:49-50 (“Maize Inbred PH2FYF”) (EX1061); US Patent No. 8,598,433, 13:3-4 (“Maize Variety Hybrid X13B604”) (EX1062); US 8,319,014, 12:60-65 (“Maize Variety Hybrid X08A201”) (EX1063); US Patent No. 8,273,948, 12:60-62 (“Maize Variety Hybrid X7M651”) (EX1064); US Patent No. 8,252,989, 40:17-18 (“Maize Variety Hybrid 10112250”) (EX1065); and US Patent No. 8,148,616, 39:53-54 (“Maize Variety Hybrid 10096210”) (EX1066).

62. It should also be noted that the specific measurement outcomes of many of the listed traits of any given inbred line will differ based on environmental conditions the plants are grown in, thus the use of comparative measurements to known lines *under the same conditions* is necessary to differentiate a particular inbred line for many of the traits in Table 1. Accordingly, slight differences in a given trait as reported in the respective Table 1 entries would not be sufficient on their own to distinguish an inbred line for many of the traits—much less to establish unexpected results as compared to the earlier lines.

2. Differences Between the Prior Art and the Claimed Invention

63. From a POSA’s perspective, any differences between the prior art and the claimed invention are insubstantial and insignificant. Both the claims and the prior art are directed to stable inbred maize varieties for use in a variety of industrial applications as well as breeding other inbred and/or hybrid lines. Indeed,

virtually all of the '020 Patent's specification is drawn verbatim from Longenberger (as indicated in the above-noted comparison, EX1093) and is also highly similar to the disclosures in Smalley and Hoffbeck.

64. Moreover, as illustrated in the above table, the disclosed characteristics of the claimed 1PFHC43 plant and its associated crop (i.e., corn ears) are highly similar to the disclosed characteristics of the identified prior art maize lines. Simply put, the disclosed properties concerning the claimed 1PFHC43 variety fall well within the mainstream of corn phenotypes observed long before the '020 Patent's 7/2/2021 effective filing date, as will become apparent in the following paragraphs 65-75, which include comparisons to both the prior art Smalley (EX1005), Longenberger (EX1006), and Hoffbeck (EX1007) patents, as well as comparisons to other sibling plant varieties (aside from Longenberger) to the claimed 1PFHC43, which are varieties that share a common parent variety (PH1D84). It should also be noted that a POSA would be familiar with extensive genetic stock collections of corn showing considerable variation with respect to the traits described in paragraphs 65-75. A POSA would therefore be able to prepare crosses with these and other known varieties to achieve variations in the traits.

65. I will now address the characteristics set forth in Table 1 "Variety Description Information" of the '020 Patent as compared to the corresponding data

for Smalley, Longenberger, and Hoffbeck, shown in the table above at paragraph 59, as well as compared to the corresponding data in various prior art “sibling” varieties sharing a parent (PH1D84) as discussed in paragraph 84 below. As an initial matter, however, I note (as also discussed in paragraph 62 above) that the data for each variety is not directly comparable given the potentially different environmental conditions in which the varieties were grown. Unlike earlier PHI patents (as discussed in more detail in Section X.A below), the ’020 Patent lacks any head-to-head data such as strip test data permitting such comparisons.

66. Grain type, flint-dent for the ’020 Patent, is the same as that reported for Hoffbeck and falls between the flint and dent types reported for Smalley and Longenberger, respectively:

TYPE:	Compared to Smalley, Longenberger, Hoffbeck	Sibling Varieties ⁷
Grain Texture (Flint-Dent)	Same as Hoffbeck; between Smalley and Longenberger.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – Dent EX1039, 10,653,094 (PH47HS) – Dent LONGENBERGER (PH47K2) – Dent EX1037, 10,154,640 (PH41V8) – Dent EX1038, 10,165,747 (PH41VW) – Dent <u>Hybrids</u>

⁷ In the charts in paragraphs 66-75, varieties are omitted where data for criteria is not available in the patent.

		EX1044, 8,772,608 (X13B660) – Flint EX1045, 8,872,005 (X08C980) – Flint-Dent EX1046, 8,895,820 (X08C981) – Flint EX1047, 8,927,829 (X08C982) – Flint-Dent EX1048, 8,946,508 (X05C050) – Flint EX1049, 9,078,408 (X08D519) – Dent EX1050, 9,084,402 (X08D522) – Flint-Dent EX1051, 9,204,604 (X13D121) – Dent EX1052, 9,370,158 (X05F864) – Dent EX1053, 9,814,197 (X13H974) – Flint to Flint-Dent EX1054, 9,861,059 (X08H824) – Flint-Dent to Dent
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67. The designation “flint-dent” indicates grain having some characteristics of both flint and dent grain. The parent (Smalley’s PH1D84) has flint grain, whereas the sibling (Longenberg’s PH47K2; Longenberger, 38:56-57) has dent grain. Accordingly, a cross of PH1D84 and another parent may be flint, dent, or an intermediate, such as flint-dent. Therefore, 1PFHC43’s flint-dent is would have been an expected and obvious result. Finally, Hoffbeck discloses the same flint-dent grain as the ’020 patent.

68. The “Maturity” section addresses criteria related to the time to various stages observed for the line. The emergence to various stages of maturity is highly dependent on a number of factors including: the geographic location where the samples were planted, the soil conditions at the site, the weather conditions prevailing that season, and when within the season the crop was planted. As a result, the “Maturity” information presented in the ’020 Patent, presented alone and

without any comparative data, does not permit a definitive conclusion as to whether any of the results is significantly different from any other. Nonetheless, the results for 1PFHC43 for most of the criteria falls within the range established by Smalley, Longenberger, and Hoffbeck. Accordingly, the Maturity data is not unexpected as compared to the data reported in Smalley, Longenberger, and Hoffbeck. Additionally, the values for 1PFHC43 also fall within the range reported for other sibling varieties, as shown in the table below.

MATURITY:	Compared to Smalley, Longenberger, Hoffbeck	Sibling Varieties
Comparative Relative Maturity (Days) (111)	Similar to Longenberger (108 days). Smalley and Hoffbeck do not report.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) - 108 EX1039, 10,653,094 (PH47HS) – 108 Longenberger (PH47K2) – 108 EX1037, 10,154,640 (PH41V8) – 108 EX1038, 10,165,747 (PH41VW) – 113 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 113 EX1045, 8,872,005 (X08C980) – 111 EX1046, 8,895,820 (X08C981) – 110 EX1047, 8,927,829 (X08C982) – 112 EX1048, 8,946,508 (X05C050) – 106 EX1049, 9,078,408 (X08D519) – 111 EX1050, 9,084,402 (X08D522) – 111 EX1051, 9,204,604 (X13D121) – 111 EX1052, 9,370,158 (X05F864) – 105 EX1053, 9,814,197 (X13H974) – 113 EX1054, 9,861,059 (X08H824) – 109

Emergence to 50% of plants in silk (days) (54)	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) - 60 EX1039, 10,653,094 (PH47HS) – 53 Longenberger (PH47K2) – 51 EX1037, 10,154,640 (PH41V8) – 62 EX1038, 10,165,747 (PH41VW) – 63
Emergence to 50% of plants in silk (heat units) (1325)	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) - 1292 EX1039, 10,653,094 (PH47HS) – 1350 Longenberger (PH47K2) – 1299 EX1037, 10,154,640 (PH41V8) – 1332 EX1038, 10,165,747 (PH41VW) – 1363 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 1327 EX1045, 8,872,005 (X08C980) – 1375 EX1046, 8,895,820 (X08C981) – 1390 EX1047, 8,927,829 (X08C982) – 1390 EX1048, 8,946,508 (X05C050) – 1405
Emergence to 50% of plants in pollen shed (days) (55)	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) - 63 EX1039, 10,653,094 (PH47HS) – 53 Longenberger (PH47K2) – 52 EX1037, 10,154,640 (PH41V8) – 67 EX1038, 10,165,747 (PH41VW) – 64
Emergence to 50% of plants in pollen shed (heat units) (1348)	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 1352 EX1039, 10,653,094 (PH47HS) – 1350 Longenberger (PH47K2) – 1325 EX1037, 10,154,640 (PH41V8) – 1462 EX1038, 10,165,747 (PH41VW) – 1388 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 1339 EX1045, 8,872,005 (X08C980) – 1390 EX1046, 8,895,820 (X08C981) – 1405 EX1047, 8,927,829 (X08C982) – 1405

		EX1048, 8,946,508 (X05C050) – 1420
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69. The next category “Plant” includes characteristics related to the corn plant. Each of these characteristics falls within the range established by Smalley, Longenberger, and Hoffbeck, or is similar to one or more of them. Additionally, the values for 1PFHC43 also fall within the range reported for sibling varieties or are similar to them, as shown in the table below. I note that length of top ear internode for 1PFHC43 is slightly shorter than the other varieties. However, the standard error for the measurement of 1.43, which means that values for other varieties fall within the 95% confidence interval for this characteristic (i.e., $\pm 1.96 \times \text{SE}$), as discussed below at paragraphs 76-79. Additionally, although length of top ear internode is used as a distinguishing characteristic, it has minimal commercial significance, at least within the range of measurements presented here. Finally, although 1PFHC43 has slightly more nodes above ground than Smalley, Longenberger, or Hoffbeck, the number falls within the range of the prior art sibling varieties and does not reflect an unexpected result from the perspective of a POSA. Brace root anthocyanin refers to pigmentation levels in a portion of corn’s root system. *See* EX1034, Merriam-Webster, 52 (definition of “anthocyanin” “any of various soluble glycoside pigments producing blue to red coloring in flowers and plants”). Specifically:

PLANT:	Compared to Smalley, Longenberger, Hoffbeck	Sibling Varieties
Plant height (cm), mean (SE) (209.3 (9.26))	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 248.2 (8.38) EX1039, 10,653,094 (PH47HS) – 202.4 (9.74) Longenberger (PH47K2) – 207 (6.1) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 321.4 (1.67) EX1045, 8,872,005 (X08C980) – 229.3 (2.05) EX1046, 8,895,820 (X08C981) – 257.6 (2.05) EX1047, 8,927,829 (X08C982) – 253.3 (2.05) EX1048, 8,946,508 (X05C050) – 254.4 (2.05) EX1049, 9,078,408 (X08D519) – 296.3 (15.75) EX1050, 9,084,402 (X08D522) – 293.1 (13.69) EX1051, 9,204,604 (X13D121) – 281.1 (20.76) EX1052, 9,370,158 (X05F864) – 273.2 (26.55) EX1053, 9,814,197 (X13H974) – 263.1 (24.27) EX1054, 9,861,059 (X08H824) – 260.5 (20.26)
Ear height (cm), mean (SE) (- 1std) (72 (6))	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 99.3 (6.43) EX1039, 10,653,094 (PH47HS) – 80.8 (4.51) Longenberger (PH47K2) – 75.1 (9.31) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 101.2 (1.69) EX1045, 8,872,005 (X08C980) – 91.6 (1.83) EX1046, 8,895,820 (X08C981) – 93.0 (1.83) EX1047, 8,927,829 (X08C982) – 92.8 (1.83) EX1048, 8,946,508 (X05C050) – 92.4 (1.83) EX1049, 9,078,408 (X08D519) – 119.6 (14.94) EX1050, 9,084,402 (X08D522) – 113 (14.45) EX1051, 9,204,604 (X13D121) – 111.8 (15.29) EX1052, 9,370,158 (X05F864) – 105.7 (15.44) EX1053, 9,814,197 (X13H974) – 122.6 (15.64) EX1054, 9,861,059 (X08H824) – 121.1 (12.17)

Length of top ear internode (cm), mean (SE) (13.6 (1.43))	Most similar to Smalley (14.7 cm)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 17.5 (1.32) EX1039, 10,653,094 (PH47HS) – 19.8 (1.57) Longenberger (PH47K2) – 16.7 (1.98) EX1037, 10,154,640 (PH41V8) – 14.3 (1.31) EX1038, 10,165,747 (PH41VW) – 16.1 (1.45) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 23.7 (0.32) EX1045, 8,872,005 (X08C980) – 18.3 (0.30) EX1046, 8,895,820 (X08C981) – 16.9 (0.30) EX1047, 8,927,829 (X08C982) – 15.5 (0.30) EX1048, 8,946,508 (X05C050) – 18.1 (0.30)
Number of nodes above ground, mean (SE) (13.3 (1.1))	Similar to Longenberger (11.9 nodes). Not reported in Smalley, Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 15.1 (0.92) EX1039, 10,653,094 (PH47HS) – 13.7 (1.15) Longenberger (PH47K2) – 11.9 (0.77) EX1037, 10,154,640 (PH41V8) – 11.6 (1.24) EX1038, 10,165,747 (PH41VW) – 14.9 (1.01)
Anthocyanin of Brace Roots (1 = absent, 2 = faint, 3 = moderate, 4 = dark) (2)	Same as Smalley, Longenberger.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 3 EX1039, 10,653,094 (PH47HS) – 2 Longenberger (PH47K2) – 2 EX1037, 10,154,640 (PH41V8) – 2 EX1038, 10,165,747 (PH41VW) – 4 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 2 EX1045, 8,872,005 (X08C980) – 2 EX1046, 8,895,820 (X08C981) – 3 EX1047, 8,927,829 (X08C982) – 2 EX1048, 8,946,508 (X05C050) – 2

70. The next category “Leaf” includes characteristics related to the corn plant’s leaves. Each of these characteristics falls within or is similar to the range established by Smalley, Longenberger, and Hoffbeck and the sibling varieties. For example, 1PFHC43’s width of ear node leaf is similar to Smalley’s 8.5 cm.

Moreover, since 1PFHC43's value is reported with a standard error of 0.62, the Smalley measurement falls within the 95% confidence interval for this value, as do the Longenberger and Hoffbeck values. Similarly, for length of ear node leaf, Longenberger's 83.9cm falls within the 95% confidence interval for 1PFHC43's value and is within the range reported for sibling varieties. Specifically:

LEAF:	Compared to Smalley, Longenberger, Hoffbeck	Sibling Varieties
Width of Ear Node Leaf (cm), mean (SE) (8.1 (0.62))	Most similar to Smalley (8.5 cm).	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 8.2 (0.57) EX1039, 10,653,094 (PH47HS) – 8.7 (0.46) Longenberger (PH47K2) – 9.3 (0.62) EX1037, 10,154,640 (PH41V8) – 8.4 (0.58) EX1038, 10,165,747 (PH41VW) – 8.9 (0.79) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 10.9 (0.15) EX1045, 8,872,005 (X08C980) – 10.8 (0.14) EX1046, 8,895,820 (X08C981) – 10.2 (0.14) EX1047, 8,927,829 (X08C982) – 10.6 (0.14) EX1048, 8,946,508 (X05C050) – 11.3 (0.14)
Length of ear node leaf (cm), mean (SE) (87.2 (2.84))	Most similar to Longenberger (83.9 cm)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 92 (2.19) EX1039, 10,653,094 (PH47HS) – 97.4 (3.57) Longenberger (PH47K2) – 83.9 (4.7) EX1037, 10,154,640 (PH41V8) – 88.7 (2.37) EX1038, 10,165,747 (PH41VW) – 85.7 (6) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 100.1 (0.69) EX1045, 8,872,005 (X08C980) – 93.8 (0.66) EX1046, 8,895,820 (X08C981) – 90.2 (0.66) EX1047, 8,927,829 (X08C982) – 93.2 (0.66)

		EX1048, 8,946,508 (X05C050) – 87.9 (0.66)
Number of leaves above top ear, mean (SE) (6.2 (0.73))	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 6.8 (0.4) EX1039, 10,653,094 (PH47HS) – 7.1 (0.59) Longenberger (PH47K2) – 5.9 (0.85) EX1037, 10,154,640 (PH41V8) – 5.8 (0.54) EX1038, 10,165,747 (PH41VW) – 7.7 (0.44) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 6.4 (0.13) EX1045, 8,872,005 (X08C980) – 5.8 (0.11) EX1046, 8,895,820 (X08C981) – 5.9 (0.11) EX1047, 8,927,829 (X08C982) – 6.6 (0.11) EX1048, 8,946,508 (X05C050) – 6.0 (0.11)
Leaf Angle (degrees), mean (SE) (29.8 (7.33))	Most similar to Longenberger (26.3 degrees)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 19.2 (3.34) EX1039, 10,653,094 (PH47HS) – 24.1 (4.02) Longenberger (PH47K2) – 26.3 (4.44) EX1037, 10,154,640 (PH41V8) – 23.4 (7.53) EX1038, 10,165,747 (PH41VW) – 24.9 (5.5) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 24.2 (0.69) EX1045, 8,872,005 (X08C980) – 25.3 (0.80) EX1046, 8,895,820 (X08C981) – 24.8 (0.80) EX1047, 8,927,829 (X08C982) – 25.0 (0.80) EX1048, 8,946,508 (X05C050) – 30.0 (0.80)
Leaf Color (V. Dark Green)	Same as Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – V. Dark Green EX1039, 10,653,094 (PH47HS) – V. Dark Green Longenberger (PH47K2) – V. Dark Green EX1037, 10,154,640 (PH41V8) – V. Dark Green EX1038, 10,165,747 (PH41VW) – V. Dark Green <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – V. Dark Green EX1045, 8,872,005 (X08C980) – V. Dark Green EX1046, 8,895,820 (X08C981) – V. Dark Green EX1047, 8,927,829 (X08C982) – V. Dark Green EX1048, 8,946,508 (X05C050) – V. Dark Green

		EX1053, 9,814,197 (X13H974) – V. Dark Green EX1054, 9,861,059 (X08H824) – V. Dark Green
Leaf Sheath Pubescence (1 - none to 9 - peach-like fuzz) (2)	Similar to Smalley (3), Hoffbeck (3). Same as Smalley (2) as reported in EX1008, 7. ⁸	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 3 EX1039, 10,653,094 (PH47HS) – 4 Longenberger (PH47K2) – 4 EX1037, 10,154,640 (PH41V8) – 3 EX1038, 10,165,747 (PH41VW) – 1 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 3 EX1045, 8,872,005 (X08C980) – 5 EX1046, 8,895,820 (X08C981) – 3 EX1047, 8,927,829 (X08C982) – 2 EX1048, 8,946,508 (X05C050) – 1

71. The next category “Tassel” includes characteristics related to the corn tassel. Each of these characteristics falls within or is similar to the range established by Smalley, Longenberger, and Hoffbeck and the sibling varieties. For example, Longenberger’s tassel length of 56.5 cm is within the 95% confidence interval for 1PFHC43 (53.5 to 67.0 cm). 1PFHC43’s tassel length also falls within the range reported for the sibling varieties. 1PFHC43’s peduncle length (25.2 cm, SE of 3.17) is statistically and functionally identical to Smalley (25.1 cm).

Specifically:

TASSEL:	Compared to Smalley, Longenberger, Hoffbeck	Sibling Varieties
Number of primary lateral	Within range of Smalley,	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 3.7 (0.9)

⁸ See above, footnote 6.

branches, mean (SE) (3 (1.47))	Longenberger, Hoffbeck	EX1039, 10,653,094 (PH47HS) – 0.9 (0.73) Longenberger (PH47K2) – 1.5 (1.24) EX1037, 10,154,640 (PH41V8) – 3.7 (1.31) EX1038, 10,165,747 (PH41VW) – 3.2 (1.01) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 5.2 (0.28) EX1045, 8,872,005 (X08C980) – 3.9 (0.29) EX1046, 8,895,820 (X08C981) – 5.4 (0.29) EX1047, 8,927,829 (X08C982) – 7.7 (0.29) EX1048, 8,946,508 (X05C050) – 4.6 (0.29) EX1052, 9,370,158 (X05F864) – 5.7 (0.58) EX1053, 9,814,197 (X13H974) – 5.7 (0.47) EX1054, 9,861,059 (X08H824) – 5.7 (0.47)
Branch angle from central spike (degrees), mean (SE) (27 (10.77))	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 38.3 (20.86) EX1039, 10,653,094 (PH47HS) – 11.8 (6.71) Longenberger (PH47K2) – 38.9 (18.73) EX1037, 10,154,640 (PH41V8) – 39 (8.27) EX1038, 10,165,747 (PH41VW) – 34 (7.18) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 26.1 (2.24) EX1045, 8,872,005 (X08C980) – 30.3 (1.85) EX1046, 8,895,820 (X08C981) – 34.3 (1.85) EX1047, 8,927,829 (X08C982) – 48.0 (1.85) EX1048, 8,946,508 (X05C050) – 38.0 (1.85)
Tassel Length (from peduncle node to tassel tip) (cm), mean (SE) (60.3 (3.45))	Most similar to Longenberger (56.5 cm)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 62.6 (3.92) EX1039, 10,653,094 (PH47HS) – 53 (2.55) Longenberger (PH47K2) – 56.5 (4.59) EX1037, 10,154,640 (PH41V8) – 51.2 (4.17) EX1038, 10,165,747 (PH41VW) – 51.4 (3.37) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 63.1 (0.78) EX1045, 8,872,005 (X08C980) – 62.2 (0.91) EX1046, 8,895,820 (X08C981) – 64.3 (0.91) EX1047, 8,927,829 (X08C982) – 62.9 (0.91) EX1048, 8,946,508 (X05C050) – 65.4 (0.91)

Peduncle Length (from top leaf node to lower branch) (cm), mean (SE) (25.2 (3.17))	Most similar to Smalley (25.1 cm)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 17.3 (1.13) EX1039, 10,653,094 (PH47HS) – 21.8 (3.83) Longenberger (PH47K2) – 21.3 (3.74) EX1037, 10,154,640 (PH41V8) – 23.5 (3.8) EX1038, 10,165,747 (PH41VW) – 25.6 (4.15) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 25.4 (0.65) EX1045, 8,872,005 (X08C980) – 30.0 (0.63) EX1046, 8,895,820 (X08C981) – 26.5 (0.63) EX1047, 8,927,829 (X08C982) – 27.2 (0.63) EX1048, 8,946,508 (X05C050) – 26.4 (0.63)
Central Spike Length (cm), mean (SE) (30.6 (3.71))	Similar to Longenberger (3096 cm). Not reported in Smalley or Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 29.5 (2.56) EX1039, 10,653,094 (PH47HS) – 22.1 (1.77) Longenberger (PH47K2) – 30.9 (3.26) EX1037, 10,154,640 (PH41V8) – 23.9 (3.45) EX1038, 10,165,747 (PH41VW) – 22.7 (4.08)
Flag Leaf Length (from flag leaf collar to tassel tip) (cm), mean (SE) (45.3 (3.32))	Similar to Longenberger (36.4 cm). Not reported in Smalley or Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 44.7 (3.41) EX1039, 10,653,094 (PH47HS) – 37.5 (2.09) Longenberger (PH47K2) – 36.4 (4.28) EX1037, 10,154,640 (PH41V8) – 36.7 (3.86) EX1038, 10,165,747 (PH41VW) – 37.7 (2.87)
Pollen Shed (0 - male sterile, 9 - heavy shed) (4)	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 2 EX1039, 10,653,094 (PH47HS) – 8 Longenberger (PH47K2) – 7 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 5 EX1045, 8,872,005 (X08C980) – 5 EX1046, 8,895,820 (X08C981) – 5 EX1047, 8,927,829 (X08C982) – 6 EX1048, 8,946,508 (X05C050) – 5
Bar Glumes (glume bands)	Same as Smalley,	<u>Inbreds</u> EX1039, 10,653,094 (PH47HS) – 1 Longenberger (PH47K2) – 1

(1 = absent, 2 = present) (1)	Longenberger, Hoffbeck	EX1037, 10,154,640 (PH41V8) – 1 EX1038, 10,165,747 (PH41VW) – 1 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 1 EX1045, 8,872,005 (X08C980) – 1 EX1046, 8,895,820 (X08C981) – 1 EX1047, 8,927,829 (X08C982) – 1 EX1048, 8,946,508 (X05C050) – 1
Anther Color (Yellow)	Most similar to Longenberger and Hoffbeck (pale yellow)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – Light Red EX1039, 10,653,094 (PH47HS) – Pale Yellow Longenberger (PH47K2) – Pale Yellow EX1037, 10,154,640 (PH41V8) – Pink-Orange EX1038, 10,165,747 (PH41VW) – Pink <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – Pink EX1045, 8,872,005 (X08C980) – Buff EX1046, 8,895,820 (X08C981) – Yellow EX1047, 8,927,829 (X08C982) – Red EX1048, 8,946,508 (X05C050) – Pink EX1053, 9,814,197 (X13H974) – Light Red EX1054, 9,861,059 (X08H824) – Pink

72. The next category “Ear (Unhusked ear)” includes characteristics related to the unhusked corn ear. Each of these characteristics falls within or is similar to the range established by Smalley, Longenberger, and Hoffbeck and the sibling varieties. Longenberger’s 20.2 cm length of interior husk falls within the 95% confidence interval for 1PFHC43 (17.6 to 24.6 cm). 1PFHC43’s length of interior husk falls within the range of the sibling varieties. Specifically:

EAR (Unhusked ear):	Compared to Smalley, Longenberger, Hoffbeck	Sibling Varieties
Silk Color (Light Red)	Same as Longenberger.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) –Light Red EX1039, 10,653,094 (PH47HS) – Pink EX1037, 10,154,640 (PH41V8) – Light Green Longenberger (PH47K2) – Light Red EX1038, 10,165,747 (PH41VW) – Light Red <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – Pink EX1045, 8,872,005 (X08C980) – Pink EX1046, 8,895,820 (X08C981) – Light Green EX1047, 8,927,829 (X08C982) – Med. Green EX1048, 8,946,508 (X05C050) – Med. Green EX1049, 9,078,408 (X08D519) – Green EX1050, 9,084,402 (X08D522) – Green EX1051, 9,204,604 (X13D121) – Red EX1052, 9,370,158 (X05F864) – Pink EX1053, 9,814,197 (X13H974) – Pink/Light Red EX1054, 9,861,059 (X08H824) – Light Green
Fresh Husk Color (Light Green)	Same as Longenberger.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – Light Green EX1039, 10,653,094 (PH47HS) – Light Green Longenberger (PH47K2) – Light Green EX1037, 10,154,640 (PH41V8) – Light Green EX1038, 10,165,747 (PH41VW) – Light Green <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – Med. Green EX1045, 8,872,005 (X08C980) – Med. Green EX1046, 8,895,820 (X08C981) – Med. Green EX1047, 8,927,829 (X08C982) – Med. Green EX1048, 8,946,508 (X05C050) – Med. Green
Dry Husk Color (White)	Same as Smalley.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – White EX1039, 10,653,094 (PH47HS) – Buff Longenberger (PH47K2) – Buff

		EX1037, 10,154,640 (PH41V8) – Buff EX1038, 10,165,747 (PH41VW) – White <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – Buff EX1045, 8,872,005 (X08C980) – White EX1046, 8,895,820 (X08C981) – White EX1047, 8,927,829 (X08C982) – White EX1048, 8,946,508 (X05C050) – White EX1053, 9,814,197 (X13H974) – Buff EX1054, 9,861,059 (X08H824) – White
Ear position at dry husk stage (1 = upright, 2 = horizontal, 3 = pedant) (1)	Same as Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 1 EX1039, 10,653,094 (PH47HS) – 2 Longenberger (PH47K2) – 1 EX1037, 10,154,640 (PH41V8) – 1 EX1038, 10,165,747 (PH41VW) – 1 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 3 EX1045, 8,872,005 (X08C980) – 1 EX1046, 8,895,820 (X08C981) – 2 EX1047, 8,927,829 (X08C982) – 1 EX1048, 8,946,508 (X05C050) – 2
Husk Tightness (1 - very loose, 9 - very tight) (6)	Same as Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 8 EX1039, 10,653,094 (PH47HS) – 7 Longenberger (PH47K2) – 7 EX1037, 10,154,640 (PH41V8) – 5 EX1038, 10,165,747 (PH41VW) – 7 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 5 EX1045, 8,872,005 (X08C980) – 6 EX1046, 8,895,820 (X08C981) – 6 EX1047, 8,927,829 (X08C982) – 6 EX1048, 8,946,508 (X05C050) – 6 EX1053, 9,814,197 (X13H974) – 6 EX1054, 9,861,059 (X08H824) – 3

Husk Extension (at harvest) (1 = short, ear exposed; 2 = medium, <8cm; 3 = long, 8-10cm; 4 = very long, >10cm) (2)	Same as Longenberger, Hoffbeck.	<u>Inbreds</u> EX1039, 10,653,094 (PH47HS) – 2 EX1037, 10,154,640 (PH41V8) – 2 Longenberger (PH47K2) – 2 EX1038, 10,165,747 (PH41VW) – 3 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 2 EX1045, 8,872,005 (X08C980) – 2 EX1046, 8,895,820 (X08C981) – 2 EX1047, 8,927,829 (X08C982) – 2 EX1048, 8,946,508 (X05C050) – 2
Length of interior husk (cm), mean (SE) (21.1 (1.8))	Similar to Longenberger (20.2 cm). Not reported in Smalley or Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 18.6 (0.78) EX1039, 10,653,094 (PH47HS) – 20.4 (1.5) Longenberger (PH47K2) – 20.2 (2.84) EX1037, 10,154,640 (PH41V8) – 23.2 (2.23) EX1038, 10,165,747 (PH41VW) – 17.5 (1.46)

73. The next category “Ear (husked ear data)” includes characteristics related to the husked corn ear. Each of these characteristics falls within or is similar to the range established by Smalley, Longenberger, and Hoffbeck and the sibling varieties. For example, Hoffbeck’s ear diameter at mid-point (42.9 cm) falls with the 95% confidence interval for the 1PFHC43 (40.9 to 46.3 cm). 1PFHC43’s value of 43.6 falls within the range reported by the sibling varieties. Specifically:

EAR (husked ear data):	Compared to Smalley, Longenberger, Hoffbeck	Sibling Varieties
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Shank Length (cm), mean (SE) (6.7 (1.66))	Within range of Smalley, Longenberger, and Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 8.1 (1.48) EX1039, 10,653,094 (PH47HS) – 9.3 (1.28) EX1037, 10,154,640 (PH41V8) – 6.1 (0.87) Longenberger (PH47K2) – 8.9 (1.79) EX1038, 10,165,747 (PH41VW) – 8 (1.38) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 10.2 (0.55) EX1045, 8,872,005 (X08C980) – 5.7 (0.39) EX1046, 8,895,820 (X08C981) – 7.0 (0.39) EX1047, 8,927,829 (X08C982) – 7.2 (0.39) EX1048, 8,946,508 (X05C050) – 8.7 (0.39)
Ear Length (cm), mean (SE) (16.5 (2.29))	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 15.2 (1.23) EX1039, 10,653,094 (PH47HS) – 15.7 (1.18) Longenberger (PH47K2) – 17 (0.87) EX1037, 10,154,640 (PH41V8) – 16.3 (1.07) EX1038, 10,165,747 (PH41VW) – 16.3 (1.38) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 18.2 (0.29) EX1045, 8,872,005 (X08C980) – 16.4 (0.31) EX1046, 8,895,820 (X08C981) – 17.0 (0.31) EX1047, 8,927,829 (X08C982) – 15.3 (0.31) EX1048, 8,946,508 (X05C050) – 16.0 (0.31)
Ear Diameter at mid-point (mm), mean (SE) (43.6 (1.38))	Most similar to Hoffbeck (42.9 cm)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 39.7 (1.66) EX1039, 10,653,094 (PH47HS) – 38.6 (1.57) Longenberger (PH47K2) – 36.1 (2.26) EX1037, 10,154,640 (PH41V8) – 38.3 (2.04) EX1038, 10,165,747 (PH41VW) – 40.4 (1.75) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 45.2 (0.45) EX1045, 8,872,005 (X08C980) – 42.4 (0.38) EX1046, 8,895,820 (X08C981) – 43.2 (0.38) EX1047, 8,927,829 (X08C982) – 45.8 (0.38) EX1048, 8,946,508 (X05C050) – 43.6 (0.38)

Ear Weight (gm), mean (SE) (149.7 (26.81))	Most similar to Hoffbeck (142.3 g)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 127.4 (18.43) EX1039, 10,653,094 (PH47HS) – 121.3 (16.43) Longenberger (PH47K2) – 107.8 (25.95) EX1037, 10,154,640 (PH41V8) – 105.8 (14.9) EX1038, 10,165,747 (PH41VW) – 123.4 (25) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 210.0 (6.14) EX1045, 8,872,005 (X08C980) – 170.4 (6.18) EX1046, 8,895,820 (X08C981) – 187.1 (6.18) EX1047, 8,927,829 (X08C982) – 173.1 (6.18) EX1048, 8,946,508 (X05C050) – 167.9 (6.18)
Number of Kernel Rows, mean (SE) (15.6 (0.99))	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 13.9 (1.48) EX1039, 10,653,094 (PH47HS) – 13.5 (0.87) Longenberger (PH47K2) – 14 (1.3) EX1037, 10,154,640 (PH41V8) – 12.4 (0.96) EX1038, 10,165,747 (PH41VW) – 13.4 (1.04) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 15.8 (0.33) EX1045, 8,872,005 (X08C980) – 13.4 (0.33) EX1046, 8,895,820 (X08C981) – 15.6 (0.33) EX1047, 8,927,829 (X08C982) – 16.4 (0.33) EX1048, 8,946,508 (X05C050) – 16.1 (0.33)
Number of Kernels per Row, mean (SE) (30.9 (6.09))	Similar to Longenberger (25.4). Not reported in Smalley, Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 31.5 (2.75) EX1039, 10,653,094 (PH47HS) – 28.8 (3.03) Longenberger (PH47K2) – 25.4 (4.85) EX1037, 10,154,640 (PH41V8) – 30.9 (2.66) EX1038, 10,165,747 (PH41VW) – 27.3 (5.49)
Kernel Rows (1 = indistinct, 2 = distinct) (2)	Same as Smalley, Longenberger, Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 2 EX1039, 10,653,094 (PH47HS) – 2 Longenberger (PH47K2) – 2 EX1037, 10,154,640 (PH41V8) – 2

		EX1038, 10,165,747 (PH41VW) – 2 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 2 EX1045, 8,872,005 (X08C980) – 2 EX1046, 8,895,820 (X08C981) – 2 EX1047, 8,927,829 (X08C982) – 2 EX1048, 8,946,508 (X05C050) – 2 EX1053, 9,814,197 (X13H974) – 2 EX1054, 9,861,059 (X08H824) – 2
Row Alignment (1 - straight, 2 - slightly curved, 3 - spiral) (2)	Same as Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 2 EX1039, 10,653,094 (PH47HS) – 1 Longenberger (PH47K2) – 1 EX1037, 10,154,640 (PH41V8) – 2 EX1038, 10,165,747 (PH41VW) – 2 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 1 EX1045, 8,872,005 (X08C980) – 2 EX1046, 8,895,820 (X08C981) – 2 EX1047, 8,927,829 (X08C982) – 2 EX1048, 8,946,508 (X05C050) – 2 EX1053, 9,814,197 (X13H974) – 1 EX1054, 9,861,059 (X08H824) – 1
Ear Taper (1 = slight cylindrical, 2 = average, 3 = extreme conical) (2)	Same as Smalley, Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 2 EX1039, 10,653,094 (PH47HS) – 1 Longenberger (PH47K2) – 1 EX1037, 10,154,640 (PH41V8) – 2 EX1038, 10,165,747 (PH41VW) – 1 <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 2 EX1045, 8,872,005 (X08C980) – 2 EX1046, 8,895,820 (X08C981) – 1 EX1047, 8,927,829 (X08C982) – 1 EX1048, 8,946,508 (X05C050) – 2

74. The next category “kernel” includes characteristics related to the dried kernel. Each of these characteristics falls within or is similar to the range established by Smalley, Longenberger, and Hoffbeck and the sibling varieties. For example, Smalley (11.2 mm) and Hoffbeck (11.1 mm) report kernel lengths falling within the 95% confidence interval for the 1PFHC43 (10.0 to 13.4 mm). Additionally, 1PFHC43’s value of 11.7 mm falls within the range reported by the sibling varieties. The weight per 100 kernels for 1PFHC43 (32.5g) is similar to Smalley (31.0 g) and falls within the range reported by the sibling varieties. Specifically:

KERNEL (Dried):	Compared to Smalley, Longenberger, Hoffbeck	Sibling Varieties
Kernel Length (mm), mean (SE) (11.7 (0.88))	Most similar to Smalley (11.2 mm), Hoffbeck (11.1 mm)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 10.8 (0.55) EX1039, 10,653,094 (PH47HS) – 10.8 (0.64) Longenberger (PH47K2) – 8.7 (1.27) EX1037, 10,154,640 (PH41V8) – 11.1 (0.62) EX1038, 10,165,747 (PH41VW) – 12.3 (0.71) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 12.7 (0.16) EX1045, 8,872,005 (X08C980) – 13.0 (0.14) EX1046, 8,895,820 (X08C981) – 13.3 (0.14) EX1047, 8,927,829 (X08C982) – 14.3 (0.14) EX1048, 8,946,508 (X05C050) – 13.3 (0.14)
Kernel Width (mm), mean (SE) (8 (0.6))	Within range of Smalley, Longenberger, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 6.7 (0.77) EX1039, 10,653,094 (PH47HS) – 7.8 (0.47) Longenberger (PH47K2) – 7.5 (0.68)

		EX1037, 10,154,640 (PH41V8) – 8.7 (0.54) EX1038, 10,165,747 (PH41VW) – 8.7 (0.51) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 7.9 (0.15) EX1045, 8,872,005 (X08C980) – 8.5 (0.13) EX1046, 8,895,820 (X08C981) – 7.9 (0.13) EX1047, 8,927,829 (X08C982) – 7.9 (0.13) EX1048, 8,946,508 (X05C050) – 7.8 (0.13)
Kernel Pericarp Color (Clear)	Same as Longenberger (colorless).	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – Colorless EX1039, 10,653,094 (PH47HS) – Colorless Longenberger (PH47K2) – Colorless EX1037, 10,154,640 (PH41V8) – Clear EX1038, 10,165,747 (PH41VW) – Clear <u>Hybrids</u> EX1053, 9,814,197 (X13H974) – Colorless EX1054, 9,861,059 (X08H824) – Colorless
Aleurone Color Pattern (Homozygous)	Same as Smalley, Longenberger, Hoffbeck.	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – Homozygous EX1039, 10,653,094 (PH47HS) – Homozygous Longenberger (PH47K2) – Homozygous EX1037, 10,154,640 (PH41V8) – Homozygous EX1038, 10,165,747 (PH41VW) – Homozygous <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – Homozygous EX1045, 8,872,005 (X08C980) – Homozygous EX1046, 8,895,820 (X08C981) – Homozygous EX1047, 8,927,829 (X08C982) – Homozygous EX1048, 8,946,508 (X05C050) – Homozygous EX1053, 9,814,197 (X13H974) – Homozygous EX1054, 9,861,059 (X08H824) – Homozygous
Aleurone Color (Clear)	Same as Longenberger	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – Yellow EX1039, 10,653,094 (PH47HS) – Clear Longenberger (PH47K2) – Clear EX1037, 10,154,640 (PH41V8) – Yellow EX1038, 10,165,747 (PH41VW) – Yellow

		<u>Hybrids</u> EX1044, 8,772,608 (X13B660) – Yellow EX1045, 8,872,005 (X08C980) – Yellow EX1046, 8,895,820 (X08C981) – Yellow EX1047, 8,927,829 (X08C982) – Yellow EX1048, 8,946,508 (X05C050) – Yellow EX1053, 9,814,197 (X13H974) – Yellow EX1054, 9,861,059 (X08H824) – Yellow
Hard Endosperm Color (Yellow)	Same as Smalley, Hoffbeck	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – Yellow EX1039, 10,653,094 (PH47HS) – Yellow Longenberger (PH47K2) – Yellow-Orange EX1037, 10,154,640 (PH41V8) – Yellow EX1038, 10,165,747 (PH41VW) – Yellow <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – Yellow EX1045, 8,872,005 (X08C980) – Yellow EX1046, 8,895,820 (X08C981) – Yellow EX1047, 8,927,829 (X08C982) – Yellow EX1048, 8,946,508 (X05C050) – Yellow EX1053, 9,814,197 (X13H974) – Yellow EX1054, 9,861,059 (X08H824) – Yellow
Weight per 100 Kernels (unsized sample) (g), mean (32.5)	Most similar to Smalley (31.0 g)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 27.8 EX1039, 10,653,094 (PH47HS) – 31.8 Longenberger (PH47K2) – 24.3 EX1037, 10,154,640 (PH41V8) – 31 EX1038, 10,165,747 (PH41VW) – 37.8

75. The next category “cob” includes characteristics related to the cob.

Each of these characteristics falls within or is similar to the range established by Smalley, Longenberger, and Hoffbeck and the other sibling varieties. For example, the 95% confidence interval for 1PFHC43’s cob diameter measurement (24.4 to 30.0 cm) overlaps with that for Hoffbeck (21.8 to 24.4 cm). In any event,

the cob several of the sibling varieties fall within the cob diameter 95% confidence interval for 1PFHC43 (24.4 to 30.0 cm). In any event, POSAs would be familiar with using the well-known and extensive corn germplasm stocks of corn to achieve a larger cob diameter, if desired. I also note that larger cob diameter is not necessarily a beneficial trait and may be a negative one. Traits of the ear such as ear diameter can result from either increases in cob size (of little or no commercial value) or kernel depth (in which case it can contribute to yield to the extent it is not offset by changes in ear length, quality, etc.). For example, I note that although mean ear diameter for 1PFHC43 is 43.6 mm as compared to 36.3 mm for the PH1D84, the difference in kernel length is only 0.5 mm, whereas the difference in cob diameter is 6.2 mm. *See* paragraph 59. For most uses, increasing the yield of grain is the primary objective and a larger cob may be detrimental by using resources that could otherwise support the grain. (Yield, however, is not disclosed in the '020 Patent even though it was reported in earlier PHI patents as discussed in Section X.A below). Indeed, it has been observed that, in the past, some farmers would inadvertently reduce their yield of grain from one year to the next by selecting large ears of corn to use for seed the following season without appreciating that the large ear was largely due to cob size rather than kernel size. Specifically:

COB:	Compared to Smalley, Longenberger, Hoffbeck	Sibling Varieties
Cob Diameter at mid point (mm), mean (SE) (27.2 (1.42))	Most similar to Hoffbeck (23.1 mm)	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – 20.2 (0.98) EX1039, 10,653,094 (PH47HS) – 20.1 (0.8) Longenberger (PH47K2) – 20.3 (1.37) EX1037, 10,154,640 (PH41V8) – 21.6 (1) EX1038, 10,165,747 (PH41VW) – 21.3 (0.95) <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – 21.8 (0.25) EX1045, 8,872,005 (X08C980) – 24.2 (0.24) EX1046, 8,895,820 (X08C981) – 24.1 (0.24) EX1047, 8,927,829 (X08C982) – 24.6 (0.24) EX1048, 8,946,508 (X05C050) – 24.8 (0.24)
Cob Color (Pink-Orange)	Within range of Smalley (white), Longenberger (white), Hoffbeck (red).	<u>Inbreds</u> EX1036, 9,848,573 (PH2RM7) – White EX1039, 10,653,094 (PH47HS) – White Longenberger (PH47K2) – White EX1037, 10,154,640 (PH41V8) – Red EX1038, 10,165,747 (PH41VW) – White <u>Hybrids</u> EX1044, 8,772,608 (X13B660) – Red EX1045, 8,872,005 (X08C980) – Pink Orange EX1046, 8,895,820 (X08C981) – Red EX1047, 8,927,829 (X08C982) – Pink Orange EX1048, 8,946,508 (X05C050) – Pink Orange EX1049, 9,078,408 (X08D519) – Pink EX1050, 9,084,402 (X08D522) – Pink EX1051, 9,204,604 (X13D121) – Red EX1052, 9,370,158 (X05F864) – Pink EX1053, 9,814,197 (X13H974) – White EX1054, 9,861,059 (X08H824) – White

76. As previewed above, statistical analysis also confirms that the traits presented in the '020 Patent, Table 1, are not significantly different from the prior art. For most of the data types, Table 1 shows a value (*i.e.*, a mean) and a standard error (SE). *See* EX1001, Table 1. With this information, it is possible to calculate a 95% confidence interval around the mean indicating, with 95% confidence, that the actual value falls within that interval.

77. When using standard error, the “95% confidence interval is obtained as the values $1.96 \times \text{SE}$ either side of the mean.” EX1035, Altman, “Standard deviations and standard errors,” *Brit. Med. J.*, 331:903 (2005).

78. If a number falls outside of the 95% confidence interval, that provides an indication that the value is at a commonly accepted level of difference to be considered statistically different from the reported value. On the other hand, if a value is inside of that range, then it is not shown to be statistically different.

79. The values reported in Smalley provide a value, standard deviation, and number of measurements. This data may be used to generate standard error using the formula: $\text{SE} = \text{SD} / \sqrt{(\text{sample size})}$. EX1035, Altman. Then, the 95% confidence interval may be calculated as $\pm 1.96 \times \text{SE}$, as described above. This analysis omits traits for which there is no statistical information, such as colors and integer values for ear position, husk tightness, and the like.

80. The results are presented in Appendix B. As shown in Appendix B, the values given for Smalley fall within the 95% confidence interval for the '020 Patent data in almost every line, indicated by the green highlighting. The only exceptions are plant height, ear height, length of ear node leaf, ear diameter at mid-point, ear weight, number of kernel rows, and cob diameter at mid-point. However, reviewing the 95% confidence interval for the Smalley data (shown in the last two columns of Appendix B) shows that the 95% confidence intervals overlap for plant height and leave only small differences for the other values (for example, 81.06 cm as compared to 81.6 cm for length of ear node leaf or 36.99 mm as compared to 40.9 mm for ear diameter). In any event, as discussed above, each of these values are still consistent with what is observed in other preexisting inbred lines. Moreover, there is no indication that the slight differences have practical significance. Indeed, the '020 Patent's specification does not indicate any such significance—much less suggest the differences constitute a surprising or unexpected result. In addition, the genetic analysis selection criteria described in the selection of the line of the '020 Patent, which I would have assumed to be the primary breeding objectives for this breeding project, did not refer to any of these traits. *See* EX1001, 38:28-30 (“ears were selected based on genetic analysis predicting disease, insect, and agronomic phenotypic performance”).

81. Notably, this analysis is highly conservative in that it (1) focuses solely on the data sets in the '020 Patent and Smalley (i.e., without any data concerning the second parent, for which no data is available) and (2) assumes for the sake of analysis that the data sets are comparable as well as repeatable (despite the different growing conditions that the datasets are likely to have come from).

82. Appendix B also shows the values for Longenberger and Hoffbeck with green highlighting showing the values falling within the 95% confidence interval for 1PFHV43's values. As reflected in Appendix B, most of the values reported in Longenberger and Hoffbeck fall within the 95% confidence interval for the 1PFHV43's values. These calculations further confirm my conclusion that the Variety Description Information reflected in the '020 Patent falls within the mainstream of what POSAs would have expected based on prior art corn varieties as of July 2021.

3. Level of Ordinary Skill in the Art

83. The level of skill in the art in the corn breeding field as of 2021 was high. *See* Section III. Consistent with that high level of skill and the routine nature of crossing inbred lines to create new varieties, including crossing inbreds to create other inbreds with similar characteristics to the parent inbred, the Patent Owner itself repeatedly used the PH1D84 variety (disclosed in Smalley) as one of the parent lines when breeding other maize varieties.

84. Specifically, the PH1D84 variety (disclosed in Smalley) is disclosed in at least eighteen other patents, including five inbred patents (EX1006, EX1036-EX1039) and eleven hybrid patents (EX1044- EX1054) issued more than one year before the '020 Patent's July 2, 2021 filing date, and another two inbred issued more recently (EX1041-EX1042), as reflected in the tables below.

Patents to Inbreds Identifying PH1D84 Variety (disclosed in Smalley) as a Parent Issued More Than One Year Before '020 Patent Filing Date		
Patent	Issuance Date	Breeding History
9,848,573 (EX1036) ("Maize Inbred PH2RM7")	2017-12-26	18:59-64 ("Inbred Maize variety PH2RM7 was developed by the following method. A cross was made between inbred line PH1D84 and inbred line PH12P9. Inbred PH2RM7 was developed by producing a doubled haploid from the F1 plants, selfing and using pedigree selection amongst the D1 lines, and selfing and bulking the subsequent generations.")
10,653,094 (EX1039) ("Maize Inbred PH47HS")	2020-05-19	38:55-61 ("Inbred Maize variety PH47HS was developed by the following method. A cross was made between inbred line PH1VMC and inbred line PH1D84. Inbred PH47HS was developed by selfing the F1 plants, and selfing and using ear-to-row (pedigree) selection from the F2 to F6 generation, and bulking the F7 seed.")
10,681,888 (EX1006) ("Maize Inbred PH47K2")	2020-06-16	38:55-61 ("Inbred Maize variety PH47K2 was developed by the following method. A cross was made between inbred line PH1D84 and inbred line PH12K5. Inbred PH47K2 was developed by producing a doubled haploid from the F1 plants, selfing and using pedigree selection amongst the D1 lines, and selfing and bulking from the subsequent generations.")

Patents to Inbreds Identifying PH1D84 Variety (disclosed in Smalley) as a Parent Issued More Than One Year Before '020 Patent Filing Date		
Patent	Issuance Date	Breeding History
10,154,640 (EX1037) ("Maize Inbred PH41V8")	2018-12-18	42:55-61 ("Inbred Maize variety PH41V8 was developed by the following method. A cross was made between inbred line PH1V69 and inbred line PH1D84. Inbred PH41V8 was developed by selfing the F1 plants, selfing and using ear to-row (pedigree) selection from the F2 to F11 generation, and bulking the F12 seed.")
10,165,747 (EX1038) ("Maize Inbred PH41VW")	2019-01-01	42:64-43:3 ("Inbred Maize variety PH41VW was developed by the following method. A cross was made between inbred line PH1D84 and inbred line PH18FC. Inbred PH41VW was developed by producing a doubled haploid from the F1 plants, selfing and using pedigree selection amongst the D1 lines, and selfing and bulking from the subsequent generations.")

Patents to Hybrids Identifying PH1D84 Variety (disclosed in Smalley) as a Parent Issued More Than One Year Before '020 Patent Filing Date		
Patent	Issuance Date	Breeding History
8,772,608 (EX1044) ("Maize Hybrid X13B660")	2014-07-08	13:16-18 ("Pioneer Brand Hybrid Maize Variety X13B660 is a single cross, yellow endosperm maize variety and can be made by crossing inbreds PH1D84 and PH12FT.")
8,872,005 (EX1045) ("Maize Hybrid X08C980")	2014-10-28	13:16-18 ("Pioneer Brand Hybrid Maize Variety X08C980 is a single cross, yellow endosperm maize variety and can be made by crossing inbreds PH1D84 and PH12TB.")
8,895,820 (EX1046) ("Maize Hybrid X08C981")	2014-11-25	13:8-10 ("Pioneer Brand Hybrid Maize Variety X08C981 is a single cross, yellow

Patents to Hybrids Identifying PH1D84 Variety (disclosed in Smalley) as a Parent Issued More Than One Year Before '020 Patent Filing Date		
Patent	Issuance Date	Breeding History
		endosperm maize variety and can be made by crossing inbreds PH1D84 and PH1C98.”)
8,927,829 (EX1047) (“Maize Hybrid X08C982”)	2015-01-06	13:8-10 (“Pioneer Brand Hybrid Maize Variety X08C982 is a single cross, yellow endosperm maize variety and can be made by crossing inbreds PH1D84 and PH1KYM.”)
8,946,508 (EX1048) (“Maize Hybrid X05C050”)	2015-02-03	13:8-10 (“Pioneer Brand Hybrid Maize Variety X05C050 is a single cross, yellow endosperm maize variety and can be made by crossing inbreds PH1D84 and PH18FN.”)
9,078,408 (EX1049) (“Maize Hybrid X08D519”)	2015-07-14	13:8-10 (“Pioneer Brand Hybrid Maize Variety X08D519 is a single cross, yellow endosperm maize variety and can be made by crossing inbreds PH1D84 and PH1M6A.”)
9,084,402 (EX1050) (“Maize Hybrid X08D522”)	2015-07-21	13:8-10 (“Pioneer Brand Hybrid Maize Variety X08D522 is a single cross, yellow endosperm maize variety and can be made by crossing inbreds PH1D84 and PH1M04.”)
9,204,604 (EX1051) (“Maize Hybrid X13D121”)	2015-12-08	13:16-18 (“Pioneer Brand Hybrid Maize Variety X13D121 is a single cross, yellow endosperm maize variety and can be made by crossing inbreds PH1D84 and PH1KVG.”)
9,370,158 (EX1052) (“Maize Hybrid X05F864”)	2016-06-21	13:16-18 (“Pioneer Brand Hybrid Maize Variety X05F864 is a single cross, yellow endosperm maize variety and can be made by crossing inbreds PH1D84 and PH1W4R.”)
9,814,197 (EX1053) (“Maize Hybrid X13H974”)	2017-11-14	15:14-16 (“Pioneer Brand Hybrid Maize Variety X13H974 is a single cross, yellow endosperm maize variety and can be made

Patents to Hybrids Identifying PH1D84 Variety (disclosed in Smalley) as a Parent Issued More Than One Year Before '020 Patent Filing Date		
Patent	Issuance Date	Breeding History
		by crossing inbreds PH1D84 and PH2DYM.”)
9,861,059 (EX1054) (“Maize Hybrid X08H842”)	2018-01-09	15:14-16 (“Pioneer Brand Hybrid Maize Variety X08H842 is a single cross, yellow endosperm maize variety and can be made by crossing inbreds PH1D84 and PH2F59.”)

Patents to Inbred Identifying PH1D84 Variety (disclosed in Smalley) as a Parent Issued Less Than One Year Before '020 Patent Filing Date		
Patent	Issuance Date	Breeding History
10,827,697 (EX1041) (“Maize Inbred PH46TZ”)	2020-11-10	38:55-61 (“Inbred Maize variety PH46TZ was developed by the following method. A cross was made between inbred line PH1KTF and inbred line PH1D84. Inbred PH46TZ was developed by producing a doubled haploid from the F1 plants, selfing and using pedigree selection amongst the D1 lines, and selfing and bulking from the subsequent generations.”)
10,869,445 (EX1042) (“Maize Inbred PH47NN”)	2020-12-22	38:61-67 (“Inbred Maize variety PH47NN was developed by the following method. A cross was made between inbred line PH1KYY and inbred line PH1D84. Inbred PH47NN was developed by selfing the F1 plants, producing a doubled haploid from the F2 generation, selfing and using pedigree selection amongst the D1 lines, and selfing and bulking from the subsequent generations.”)

85. Likewise, Patent Owner also used the PH1VNA variety (i.e., the other parent—aside from PH1D84—used to create the claimed 1PFHC43 variety) for at least one other cross, as disclosed in a separate patent application filed the same day as that for the '020 Patent. *See* US Patent No. 11,696,545 (EX1043), 37:61-38:3 (“Inbred Maize variety PH4CYJ was developed by the following method. PH4CYJ is an elite corn inbred line originated from a cross between inbred line PH1KTF and inbred line PH1VNA. From this cross, ears were selected based on genetic analysis predicting disease, insect, and agronomic phenotypic performance. Inbred PH4CYJ was developed by producing a doubled haploid from the F1 plants, selfing and using pedigree selection amongst the D1 lines, and selfing and bulking from the subsequent generations.”)

86. Corn breeding indeed was a sophisticated science by 2021, with multi-disciplinary teams harnessing computational biology and sophisticated understandings of the corn genome (which had been sequenced in 2009, per EX1018, Schnable et al., “The B73 Maize Genome: Complexity, Diversity, and Dynamics,” *Science*, 2009, 326:1112) to create new varieties incorporated desired phenotypical features. These breeding efforts focused not only on the hybrid varieties sold to farmers, but also the “inbred” varieties used as the basis to create future hybrids.

87. As stated in both the '020 Patent and the virtually identical Longenberger prior art, “[a] continuing goal of maize breeders is to develop stable, high yielding maize varieties and hybrids that are agronomically sound with maximal yield over one or more different conditions and environments.” EX1001, 1:23-26; EX1006, 1:23-26. Given the competitive nature of the market, constant evolution and improvement of a company’s inbred lines was a commercial imperative.

88. And the high level of skill in the modern corn breeding field confirms such capability—POSAs were capable of breeding inbred lines to create essentially any desired inbred phenotypical trait in descendent inbred lines, at least within the ranges made possible by the existing gene pool as confirmed by the existence of the trait in one or more preexisting corn varieties (as is the case with all of the identified characteristics in the '020 Patent, as discussed in paragraphs 63 above). For example, changes in grain color could be incorporated via established techniques such as locus conversions. EX1005, 16:46-49 (“Desired traits that may be transferred through locus conversion include...grain color (white)”); EX1006, 20:14-22 (same); EX1007, 18:6-15 (same).

4. Secondary Considerations

89. The '020 Patent’s specification does not suggest any purportedly unexpected results or other potential secondary considerations of non-obviousness.

On the contrary, the minor variations reflected in the reported properties of the claimed variety as compared to prior art varieties are well within the bounds of what a POSA would expect in the ordinary course of plant breeding.

90. As an initial matter, the '020 Patent does not report comparative data that would be useful in assessing the performance or utility of the claimed variety. For example, Table 1 only shows values for the claimed variety and no comparative data. Table 1 also does not include characteristics such as seeding vigor or stand count that might be used to show superior characteristics for an inbred line, much less grain yield stalk quality, or other key agronomic traits of a commercial corn hybrid, nor does it list performance for the traits included in the genetic analysis-based section of disease, insect, and agronomic phenotypic performance. *See* EX1001, 38:28-30. The '020 Patent also does not report data about the performance of any hybrids developed from the claimed inbreds. Data about hybrids would be critical to determining the value of the inbred. For example, the hybrid might be judged with respect to characteristics such as selection index, yield, percentage moisture, disease, insect, agronomic phenotypic performance, and percentage barren plants. None of these are presented in the '020 Patent.

B. Ground 1: Claims 1-20 Are Unpatentable as Obvious Over Smalley (EX1005) and the Corresponding PVPA Certificate (EX1008)

91. Smalley and the corresponding PVPA Certificate disclose PH1D84—one of the two parent varieties of the 1PFHC43 variety claimed in the '020 Patent.

92. Smalley discloses that PH1D84 can be used “[t]o Develop Another Maize Plant” and in particular is a “source of breeding material that may be used to develop new maize inbred varieties.” EX1005, 28:30-35. It also discloses specific cross breeding techniques for producing such “new inbred” varieties. EX1005, 2:43-49. In particular, Smalley discloses using PH1D84 to derive new maize seeds that are genetically and physically similar to PH1D84. EX1005, 31:22-49.

93. Smalley discloses that it is beneficial to further breed PH1D84:

The development of a maize hybrid in a maize plant breeding program involves three steps: (1) the selection of plants from various germplasm pools for initial breeding crosses; (2) the selfing of the selected plants from the breeding crosses for several generations to produce a series of varieties, such as PH1D84, which, although different from each other, breed true and are highly uniform; and (3) crossing the selected varieties with different varieties to produce the hybrids. **During the inbreeding process in maize, the vigor of the varieties decreases, and so one would not be likely to use PH1D84 directly to produce grain. However, vigor is restored when PH1D84 is crossed to a different inbred variety to produce a commercial F1 hybrid. An important consequence of the homozygosity and homogeneity of the**

inbred variety is that the hybrid between a defined pair of inbreds may be reproduced indefinitely as long as the homogeneity of the inbred parents is maintained.

EX1005, 14:64-15:13 (emphasis added).

94. Consistent with these disclosures, PH1D84 had repeatedly been used as one of the parents for other maize varieties, including at least seven inbreds (five of which I understand constitute indisputable prior art issued more than a year before the '020 Patent's July 2, 2021 filing date) and eleven hybrids (all indisputable prior art issued more than a year before the '020 Patent's July 2, 2021 filing date). Paragraph 84 above includes a table reflecting such previous crosses.

95. As Smalley itself discloses and these other crosses confirm, POSAs would have had reasons to use PH1D84 as the starting point to create other inbred lines.

96. POSAs would have had a reasonable expectation of obtaining an inbred maize variety with PH1D84 as a parent, particularly given (1) the routine nature of the breeding techniques involved and (2) the multiple other instances already reported in which PH1D84 had been used as a parent to obtain other inbred lines.

1. Claim 1: Variety 1PFHC43

97. Claim 1 encompasses a seed, plant part, or plant cell of variety 1PFHC43. Variety 1PFHC43's disclosed characteristics are highly similar to those

in the PH1D84 parent, and nothing in the specification or otherwise in the intrinsic record suggests any property that a POSA familiar with well-known breeding techniques and the prior art as described herein would have viewed as surprising or unexpected over PH1D84. See paragraphs 65-82 above. The record does not explain the significance of any differences between the claimed variety and known varieties. To the extent such differences exist, there is no basis from which to conclude they are significant or unexpected as compared to the PH1D84 variety disclosed in Smalley and touted therein as a potential starting point for future inbred lines.

98. Indeed, none of the differences have any material commercial significance. In particular, none of them are relevant to the underlying goal identified in the '020 Patent of developing “stable, high yielding maize varieties and hybrids that are agronomically sound with maximal yield over one or more different conditions and environments.” EX1001, 1:23-26. Nor are they relevant to the nature of the '020 Patent’s disclosed “Industrial Applicability.” EX1001, 36:49-37:26.

99. For example, while Smalley discloses a plant height of 209.3 cm and Smalley discloses a plant height of 179.5 cm, the height of an inbred variety, at least within the range exhibited by these two varieties, is of marginal relevance (at most) to the value of an inbred variety. Because the '020 patent presents no data

on hybrid crosses of the '020 Patent, it is impossible to determine the degree to which any height variation is inherited by hybrid crosses of the 1PFHC43 and, to the extent it is inherited, what impact it has on performance of the hybrid cross. Similarly, characteristics of the ear of the 1PFHC43 (such as ear diameter and ear weight) are only relevant to the extent that are inherited in the hybrid cross, which is not disclosed in the '020 Patent. Even then, the traits are only commercially relevant if they impact yield or other value hybrid characteristics.

100. Accordingly, claim 1 would have been obvious over Smalley and the corresponding PVPA Certificate.

101. I have been informed that the Examiner distinguished the claimed 1PFHC43 over varieties in the prior art EX1040, U.S. Patent No. 6,252,148 (claiming LH244) on the basis that “instant 1 PFHC43 has/have flint-dent grain, slightly curved rows, and clear aleurone; while the LH244 has/have straight rows, white aleurone and dent grain.” Further, that the Examiner distinguished the claimed 1PFHC43 over varieties in the prior art EX1059, US Patent Publication No. 2005/0257298 (claiming PHACE) on the basis that “[t]hey can be distinguished, however, at least on the basis of flint-dent grain versus dent grain.” These distinguishing features are not a basis to distinguish the '020 Patent's 1PFHC43 from Smalley for the following reasons:

- a. Grain Texture. 1PFHC43 is described as flint-dent, whereas Smalley is described as flint. “Flint” and “dent” are terms that describe two different grain types, particular varieties may have some combination of the characteristics associated with each type, as indicated by the “flint-dent” description for 1PFHC43.⁹ As shown in the chart at paragraph 66, prior art crosses of PH1D84 (including inbreds and hybrids) exhibit dent, flint, flint-dent, “flint to flint-dent” and “flint-dent to dent” character. Accordingly, 1PFHC43’s “flint-dent” character is one expected result for an offspring of PH1D84.
- b. Row Alignment. Row alignment is assignment a “1” for straight, “2” for slightly curved and “3” for spiral. 1PFHC43 has a “2” and Smalley has a “1.” As shown in the chart at paragraph 73, prior art crosses of PH1D84 exhibit both “1” and “2” row assignments.

⁹ Flint is a hard textured grain and it can be a range of colors from white to deep yellow or even purple. It tends to have very smooth and firm kernel forms. Dent has softer grain, can have flowery grain texture, and tends to have wrinkled textures such as indented kernel caps and square or shrunken kernel characteristics. A flint-dent would be more flint than dent in character and a dent-flint would be more dent than flint.

Accordingly, 1PFHC43's "2" row alignment is one expected result for an offspring of PH1D84.

- c. Aleurone Color. 1PFHC43 is described as having a clear aleurone color, whereas Smalley has a yellow aleurone color.¹⁰ For many applications, the color of the aleurone is entirely irrelevant. Whether or not the aleurone color matters at all depends in part on the color of the endosperm.¹¹ The color of the endosperm and aleurone together have some relevance to a food-grade crop because some customers may prefer to use either white corn or yellow corn for consistency of a product's appearance. In the case of white food grade corn, a clear aleurone may be preferred so as not to give a yellow color to the

¹⁰ Aleurone refers to a separate internal layer closer to the surface, but still not exposed. *See* EX1034, Merriam-Webster, 30 (definition of "aleurone" "protein matter in the form of minute granules or grains occurring in seeds in endosperm or in a special peripheral layer").

¹¹ Endosperm refers to a corn seed's starchy interior. *See* EX1034, Merriam-Webster, 412 (definition of "endosperm" "a nutritive tissue in seed plants formed within the embryo sac by division of the endosperm nucleus").

product. However, the 1PFHC43 has yellow endosperm, so the product would also be yellow, regardless of the clear color of the aleurone. Smalley discloses a yellow endosperm and aleurone.

Accordingly, the combination of yellow endosperm and clear aleurone for 1PFHC43 does not constitute a material difference over Smalley's PH1D84 variety with its yellow endosperm and aleurone.

Additionally, the aleurone color differences in the discussed range represent a trait that would be easily incorporated in a corn variety by a POSA.

The anther is simply the pollen-containing structure within a male flower (called a "tassel"). See EX1034, Merriam-Webster, 52 (definition of "anther" "the part of a stamen that produces and contains pollen and is usu. borne on a stalk"). The color of the anther does not have any technical or commercial significance to the crop. It is used for identification purposes only.

102. As discussed above at paragraphs 63-82, each of the characteristics shown in the '020 Patent, Table 1 is either within the range established by the prior art, is not technically or economically relevant, or both.

103. Accordingly, claim 1 would have been obvious over Smalley and the corresponding PVPA Certificate.

2. Claims 2-20: Variations and Hybrids Related to 1PFHC43

104. Claims 2-20 likewise would have been obvious over Smalley and the corresponding PVPA Certificate. They recite variations, hybrids, and related methods concerning the claimed inbred line:

Claim 2
The plant part of claim 1, wherein the plant part is an ovule or the plant part is pollen.
Claim 3
An F1 hybrid maize seed produced by crossing the plant or plant part of claim 1 with a different maize plant.
Claim 4
An F1 hybrid maize plant or plant part produced by growing the maize seed of claim 3, wherein the plant part comprises at least one cell of the F1 hybrid maize plant.
Claim 5
A method for producing a second maize plant, the method comprising applying plant breeding techniques to the F1 plant or plant part of claim 4 to produce the second maize plant.
Claim 6
A method for producing a second maize plant or plant part, the method comprising doubling haploid seed generated from a cross of the plant or plant part of claim 4 with an inducer variety, thereby producing the second maize plant or plant part.
Claim 7
A method of making a commodity plant product comprising silage, starch, fat, syrup or protein, the method comprising producing the commodity plant product from the maize plant or plant part of claim 4.
Claim 8
A method of producing a maize seed derived from the variety 1PFHC43, comprising:
a) crossing the plant of claim 1 with itself or a second plant to produce progeny seed; and

b) growing the progeny seed to produce a progeny plant and crossing the progeny plant with itself or a different plant to produce maize seed derived from the variety 1PFHC43.
Claim 9
A method for producing nucleic acids, the method comprising isolating nucleic acids from the seed, plant, plant part, or plant cell of claim 1.
Claim 10
A converted seed, plant, plant part or plant cell of inbred maize variety 1PFHC43, representative seed of the maize variety 1PFHC43 having been deposited under NCMA accession number 202212064,
wherein the converted seed, plant, plant part or plant cell comprises fewer than six locus conversions,
and wherein the plant or a plant grown from the converted seed, plant part or plant cell comprises the fewer than six locus conversions and otherwise comprises the physiological and morphological characteristics of maize variety 1PFHC43 when grown under the same environmental conditions,
and further wherein the fewer than six locus conversion confer a property selected from the group consisting of male sterility, a site for site-specific recombination, abiotic stress tolerance, altered phosphate, altered antioxidants, altered fatty acids, altered essential amino acids, altered carbohydrates, herbicide tolerance, insect resistance and disease resistance.
Claim 11
The converted seed, plant, plant part or plant cell of claim 10, wherein the fewer than six locus conversions confer a property selected from the group consisting of herbicide tolerance, insect resistance and disease resistance.
Claim 12
A maize seed produced by crossing the plant or plant part of claim 10 with a different maize plant.
Claim 13
A hybrid maize plant or plant part produced by growing the seed of claim 12, wherein the plant part comprises at least one cell of the hybrid maize plant.
Claim 14
A method for producing a second maize plant, the method comprising applying plant breeding techniques to the plant or plant part of claim 13 to produce the second maize plant.

Claim 15
A method for producing a second maize plant or plant part, the method comprising doubling haploid seed generated from a cross of the plant or plant part of claim 13 with an inducer variety, thereby producing the second maize plant or plant part.
Claim 16
A method of making a commodity plant product comprising silage, starch, fat, syrup or protein, the method comprising producing the commodity plant product from the maize plant or plant part of claim 13.
Claim 17
A method for producing nucleic acids, the method comprising isolating nucleic acids from the seed, plant, plant part, or plant cell of claim 10.
Claim 18
An F1 hybrid seed produced by crossing a plant or plant part of inbred maize variety 1PFHC43, representative seed of the inbred maize variety 1PFHC43 having been deposited under NCMA accession number 202212064 with a different maize plant,
wherein inbred maize variety 1PFHC43 further comprises a transgene and otherwise comprises all of the physiological and morphological characteristics of maize variety 1PFHC43 when grown under the same environmental conditions,
wherein the transgene is inherited by the F1 hybrid seed,
wherein the transgene was introduced into inbred maize variety 1PFHC43 by backcrossing or genetic transformation.
Claim 19
A method of producing progeny seed, the method comprising crossing a plant grown from the seed of claim 18 with itself or a second plant to produce progeny seed.
Claim 20
A method of making a commodity plant product comprising silage, starch, fat, syrup or protein, the method comprising producing the commodity plant product from the maize plant or plant part of claim 18.

105. Claims 2-20 indeed essentially mirror analogous claim sets in multiple prior art patents (U.S. Patent Nos 10,492,410 (EX1067); 10,492,411 (EX1068); 10,492,412 (EX1069); 10,492,413 (EX1070); and 10,492,414 (EX1071)) directed

to other inbred corn varieties—confirming that using and/or modifying the 1PFHC43 inbred line in those ways likewise would have been obvious.

a. Claim 2: Ovule or Pollen From the Inbred Line of Claim 1

106. Claim 2 depends from claim 1 and requires that “the plant part” be “an ovule” or “pollen.” Smalley discloses that a “plant part” includes “pollen” and “ovules.” EX1005, 9:6-9. POSAs would have recognized that inbred lines created from PH1D84 likewise include both ovules and pollen. *See also* EX1067, U.S. Patent No. 10,492,410, 44:4-6 (“wherein the plant part is an ovule or pollen”).

b. Claims 3-8: Hybrids and Related Uses Derived From the Inbred Line of Claim 1

107. Claim 3 is to “[a]n F1 hybrid maize seed produced by crossing the plant or plant part of claim 1 with a different maize plant.” Smalley discloses that hybrids are generated by crossing two inbred varieties (such as PH1D84 itself and/or other inbred lines such as those Smalley discloses can be created using PH1D84 as the starting point. *See* EX1005, 12:48-49 (“Inbred maize variety PH1D84 may be used as a male or female in the production of the first generation F1 hybrid.”), 28:30-35. Further, Smalley discloses that “F1” hybrids—meaning the “first generation” of the cross—are the focus when developing “commercial hybrids” because they are “more vigorous than their inbred parents.” EX1005, 14:42-50. Indeed, Smalley discloses details about hybrids. *See* EX1005, 15:56-

16:6 (Hybrid Comparisons), Table 3. Claim 3 is obvious in view of these disclosures in addition to the above-discussed reasons concerning claim 1. POSAs would have had reason to create the 1PFHC43 inbred variety using PH1D84 as the starting point, and would further have had reason to use that inbred variety to create F1 hybrid seeds for commercialization.

108. Claim 4 is to a plant or plant part produced by growing the F1 hybrid seed of claim 3, and in particular to “at least one cell of the F1 hybrid maize plant.” It is obvious for the same reasons as claim 3 given that the purpose of creating an F1 hybrid seed is to grow an F1 hybrid plant.

109. Claim 5 concerns “[a] method for producing a second maize plant” by “applying plant breeding techniques to the F1 plant or plant part of claim 4.” Claim 5 would have been obvious given Smalley’s disclosure that plant breeding techniques can be used to cross an “F1 hybrid” with either another F1 hybrid or another inbred line. EX1005, 15:14-24.

110. Claim 6 concerns “[a] method for producing a second maize plant or plant part, the method comprising doubling haploid seed generated from a cross of the plant or plant part of claim 4 with an inducer variety.” Claim 6 would have been obvious for the same reasons as claim 5 and in further view of Smalley’s disclosure of the use of “Haploid induction systems” for maize in which “haploid plants from any genotype” may be created “by crossing a selected variety (as

female) with an inducer variety.” EX1005, 30:24-38. Smalley’s claim 8 likewise parallels challenged claim 6 and further confirms the obviousness of crossing an inbred maize line, F1 hybrid or other derived breeding materials with an inducer variety to produce haploid seed. EX1005, 42:32-36.

111. Claim 7 concerns “[a] method of making a commodity plant product comprising silage, starch, fat, syrup or protein, the method comprising producing the commodity plant product from the maize plant or plant part of claim 4.” Claim 7 would have been obvious for the same reasons as claim 4 in further view of Smalley’s disclosure that the invention included a “method of harvesting the grain of the F1 plant of variety PH1D84 and using the grain in a commodity,” such as “starches, syrups, proteins, and sugars.” EX1005, 34:3-7. POSAs would have understood that F1 hybrids created from the inbred line of claim 1 (which would have been obvious as discussed above) could be used for the same generic application.

112. Claim 8 concerns “[a] method of producing a maize seed derived from the variety 1PFHC43, comprising: (a) crossing the plant of claim 1 with itself or a second plant to produce progeny seed; and (b) growing the progeny seed to produce a progeny plant and crossing the progeny plant with itself or a different plant to produce maize seed derived from the variety 1PFHC43.” Claim 8 would have been obvious for the same reasons as claim 5, which concerns a more specific

method of generating a second-generation progeny plant derived from 1PFHC43 in which the first-generation plant is an F1 hybrid. *See also* EX1005, 42:8-6 (Smalley's claims 3-6).

113. Claims 3-8 likewise mirror analogous claim sets in multiple prior art patents directed to other inbred corn varieties—further confirming that it would have been obvious to use the 1PFHC43 variety (itself obvious as detailed in Section IX.B.1) for hybridization purposes as claims 3-8 specify:

Claim in '020 Patent	Analogous Claim in each of EX1067-EX1070¹²
3	3
4	5
5	6
6	7
7	8
8	9 ¹³

¹² U.S. Patent No. 10,492,410 (EX1067); U.S. Patent No. 10,492,411 (EX1068); U.S. Patent No. 10,492,412 (EX1069); U.S. Patent No. 10,492,413 (EX1070); and U.S. Patent No. 10,492,414 (EX1071).

¹³ Claim 9 in the prior art discloses an additional step of an additional cross to create a subsequent generation, but encompasses the steps of challenged claim 8.

c. Claim 9: Nucleic Acids Isolated From 1PFHC43

114. Claim 9 concerns “[a] method for producing nucleic acids” by “isolating nucleic acids from the seed, plant, plant part, or plant cell of claim 1.” Claim 9 would have been obvious for the same reasons as claim 1 in view of a POSA’s knowledge that it was routine to isolate nucleic acids from inbred maize lines—as confirmed by Smalley. EX1005, 8:52-54 (defining nucleic acid as “[a]n acidic, chainlike biological macromolecule...”); *see also* EX1067, U.S. Patent No. 10,492,410, 44:42-44 (“method for producing nucleic acids, the method comprising isolating nucleic acids from the seed, plant, plant part, or plant cell of claim 1”); EX1072, U.S. Patent No. 10,011,828, Abstract (“isolating DNA from biological materials such as seeds”); EX1073, U.S. Patent No. 8,927,214, Title (“Method and compositions for dual extraction of protein and nucleic acid”).

d. Claims 10-17: Converted Seeds of 1PFHC43

115. Claim 10 concerns “[a] converted seed, plant, plant part or plant cell of inbred maize variety 1PFHC43” with “fewer than six locus conversions” such that the plant or plant grown from such seed “comprises the physiological and morphological characteristics of maize variety 1PFHC43 when grown under the same environmental conditions, and further wherein the fewer than six locus conversions confer a property selected from the group consisting of male sterility,

a site for site-specific recombination, abiotic stress tolerance, altered phosphate, altered antioxidants, altered fatty acids, altered essential amino acids, altered carbohydrates, herbicide tolerance, insect resistance and disease resistance.”

116. Claim 10 would have been obvious for the same reasons as claim 1 (concerning variety 1PFHC43) in further view of a POSA’s knowledge that locus conversions such as those recited in claim 10 were a routine technique to incorporate desirable traits into inbred maize lines—as further confirmed by Smalley’s disclosure that “[o]ne or more locus conversion traits” such as “male sterility, insect control, disease control or herbicide tolerance” can “be introduced into a single corn variety.” EX1005, 7:43-52; *see also id.*, 16:46-60; 16:60-64 (“triple stacks” of loci); 42:51-57 (claim to inbred variety PH1D84 with “a locus conversion” that “confers a trait selected” from the same group of traits recited in challenged claim 10). Further, locus conversion technology was sufficiently advanced such that the additional trait(s) could be introduced without impacting the plant’s “physiological and morphological characteristics.”

117. Prior art U.S. Patent Nos 10,492,410 (EX1067); 10,492,411 (EX1068); 10,492,412 (EX1069); 10,492,413 (EX1070); and 10,492,414 (EX1071) all include essentially identical claims, including the same list of properties and the same limitation on the number of locus conversions—further confirming the obviousness of incorporating such locus conversions into inbred

lines such as 1PFHC43. EX1067, 44:45-61; EX1068, 44:42-58; EX1069, 44:32-48; EX1070, 44:36-52; EX1071, 44:34-50.

118. Claim 11 depends from claim 10 and requires that the “fewer than six locus conversions confer a property selected from the group consisting of herbicide tolerance, insect resistance, and disease resistance.” It would have been obvious to a POSA to select a property “from the group consisting of herbicide tolerance, insect resistance, and disease resistance” at least because Smalley identified these three as “traits of interest.” EX1005, 14:34-35 (referring to “traits of interest such as herbicide tolerance, insect or disease resistance”). The obviousness of claim 11 is further confirmed by the inclusion of an analogous dependent claim—reciting the exact same three-member group—in other of PO’s prior art patents. E.g., EX1042, U.S. Patent No. 10,869,445, 42:17-21; EX1067, 44:62-65.

119. Claims 12-17 depend directly or indirectly from claim 10 and otherwise parallel the limitations of claims 3-7 and 9, respectively. They would have been obvious for the same reasons as claim 10 and in further view of the above-discussed reasons why dependent claims 3-7 and 9 would have been obvious. The above discussions apply equally to converted seeds incorporating locus conversions, which impart additional properties but otherwise do not impact the variety or how it can be used. PO’s other prior art patents likewise include analogous dependent claims. E.g., EX1071, 44:62-45:11.

**e. Claims 18-20: F1 Hybrid Derived From Variety
1PFHC43 with a Transgene**

120. Much like dependent claim 3, claim 18 recites an F1 hybrid seed produced by crossing a plant or plant part of 1PFHC43 with another variety. However, it includes the additional requirement that (1) “the 1PFHC43 further comprises a transgene and otherwise comprises all of the physiological and morphological characteristics of maize variety 1PFHC43 when grown under the same environmental conditions, wherein the transgene is inherited by the F1 hybrid seed”; and (2) the transgene be incorporated by “backcrossing or genetic transformation.” As Smalley discloses, incorporating a transgene into a corn variety is one particular technique for incorporating a locus conversion (as discussed in connection with claim 10). EX1005, 7:43-52. Smalley also discloses that backcrossing is a technique for incorporating locus conversions in general and transgenes in particular. EX1005, 16:14-36. Claim 18 would have been obvious for the same reasons as above-discussed claims 3 and 10 and in further view of these additional disclosures in Smalley. PO’s other prior art patents likewise include claims directed to the inclusion of a “transgene” incorporated “by backcrossing or genetic transformation.” *E.g.*, EX1071, 44:9-14.

121. Claim 19 concerns “[a] method of producing progeny seed” by “crossing a plant grown from the seed of claim 18 with itself or a second plant to produce progeny seed.” It parallels above-discussed claim 5 aside from (1) the

more specific requirement concerning the nature of the starting F1 hybrid seed; and
(2) the fact that claim 19 refers to “progeny seed” rather than a “plant” itself.
Claim 19 accordingly would have been obvious for the reasons discussed above in connection with claims 5 and 19.

122. In particular, POSAs would have understood that Smalley’s disclosure that plant breeding techniques can be used to cross an “F1 hybrid” with either another F1 hybrid or another inbred line (EX1005, 15:14-24) was applicable to F1 hybrids created by crossing inbred varieties incorporating transgenes.

123. Claim 20 parallels claim 7 (i.e., “a method of making a commodity plant product...”) aside from reciting the plant of claim 18 rather than claim 4. Claim 20 would have been obvious for the same reasons as claim 7.

C. Ground 2: Claims 1-20 Are Unpatentable As Obvious Over Longenberger (EX1006) and the Corresponding PVPA Certificate (EX1009)

124. Longenberger and the corresponding PVPA Certificate disclose PH47K2—a prior art inbred variety with traits very similar to those of the 1PFHC43 variety claimed in the ’020 Patent. Longenberger is a sibling of the ’020 patent’s 1PFHC43 because they each share the parent PH1D84. EX1001, 38:25-34; EX1006, 38:55-61.

125. Longenberger discloses that PH47K2 can be used “to Develop Another Maize Plant” and in particular is a “source of breeding material that may

be used to develop new maize inbred varieties.” EX1006, 32:38-43. It also discloses specific cross breeding techniques for producing such “new inbred” varieties. *Id.*, 5:38-45. In particular, Longenberger discloses using PH47K2 to derive new maize seeds that are genetically and physically similar to PH47K2. EX1006, 18:19-19:44.

126. Consistent with these disclosures, PH47K2 was previously used as one of the parents for another maize variety—a hybrid line disclosed in prior art. EX1060, US Patent No. 10,863,705, 11:19-24.

127. As Longenberger itself discloses and these other crosses—including but not limited to that disclosed in indisputable prior art—confirm, POSAs would have had reason to use PH47K2 as the starting point to create other inbred lines. The nature of the maize market confirms the reasons to create a wide array of new varieties using PH47K2 as the starting point.

128. POSAs would have had a reasonable expectation of obtaining an inbred maize variety with PH47K2 as a parent, particularly given (1) the routine nature of the breeding techniques involved, (2) Longenberger’s disclosure that its claimed variety can be “used to develop new maize inbred varieties” (EX1006, 32:38-43) and (3) the previous instance already reported in which PH1D84 had been used as a parent to obtain another line.

1. Claim 1

129. Claim 1 encompasses a seed, plant part, or plant cell of variety 1PFHC43. 1PFHC43's disclosed characteristics are highly similar to PH47K2's as disclosed in Longenberger, and nothing in the '020 Patent's specification or otherwise in the intrinsic record suggests any property of 1PFHC43 that POSAs would have viewed as surprising, unexpected, or commercially valuable over PH47K2. *Supra* §IX.A.2. The record does not explain the significance of any differences between the claimed variety and known varieties. To the extent such differences exist, there is no basis from which to conclude they are significant or unexpected as compared to the PH47K variety disclosed in Longenberger and touted therein as a potential starting point for future inbred lines.

130. Comparing the values disclosed in Longenberger against the 95% confidence intervals for the values disclosed in the '020 Patent shows that most of the values fall within the confidence interval. *See* Appendix B (green highlighting indicating values within range). This demonstrates that the differences for most measurements are likely not statistically significant. The only characteristics falling outside the 95% confidence interval are: length of top ear internode, flag leaf length, and cob diameter. *See* Appendix B. However, there is no indication, even if these characteristics are physically different, that the differences have any meaning to the performance of the plant or have any commercial significance. Of

course, it remains unclear the degree to which any difference may be due to difference in growing conditions and location for the samples. In any event, as discussed for the respective characteristics at paragraphs 65-75, the values for 1PFHC43 all fall within or are similar to the ranges established by the prior art.

131. Indeed, none of the differences have any material commercial significance. In particular, none of them are relevant to the underlying goal identified in the '020 Patent of developing “stable, high yielding maize varieties and hybrids that are agronomically sound with maximal yield over one or more different conditions and environments.” EX1001, 1:23-26. Nor are they relevant to the nature of the '020 Patent’s disclosed “Industrial Applicability.” EX1001, 36:20-65.

132. Again considering the three characteristics relied upon by the Examiner (see paragraph 101), I conclude that these features are not a basis to distinguish the '020 Patent’s 1PFHC43 from Longenberger for the following reasons:

- a. Grain Texture. 1PFHC43 is described as flint-dent, whereas Longenberger is described as dent. A POSA would be able to achieve a flint-dent cross from a dent parent. Indeed, hybrid X08N769, a hybrid cross of Longenberger’s PH47K2 is characterized as having grain type flint-dent. EX1060, US 10,863,705, 32:60-62, Table 1.

b. Row Alignment. Row alignment is assignment a “1” for straight, “2” for slightly curved and “3” for spiral. 1PFHC43 has a “2” and Longenberger has a “1.” A POSA would be able to obtain a variety having a slightly curved row alignment from a parent having a straight row variety. This is demonstrated above in the examples of the inbred and hybrid crosses of Smalley’s PH1D84 (having a row alignment of “1”) exhibiting both “1” and “2” row assignments. *See above*, paragraph 73. Accordingly, 1PFHC43’s “2” row alignment is one expected result for an offspring of PH47K2.

c. Aleurone Color. 1PFHC43 and PH47K2 both have clear aleurone.

133. As discussed above at paragraphs 63-82, each of the characteristics shown in the ’020 Patent, Table 1 is either within the range established by the prior art, is not technically or economically relevant, or both. Accordingly, claim 1 would have been obvious over Longenberger.

2. Claims 2-20

134. Claims 2-20 are likewise unpatentable as obvious over Longenberger for the same reasons detailed immediately above concerning claim 1 and for the additional reasons explained in §IX.B.2 concerning why claims 2-20 are obvious over Smalley and as further confirmed by PO’s other prior art patents (EX1067-1071) including analogous claims related to other inbred corn lines. Smalley has

disclosures paralleling the disclosures in Smalley identified in §IX.B.2 concerning claims 2-20.

135. In particular:

	Relevant Disclosures in Longenberger (EX1006)
Claim 2	12:40-47 (“plant part” includes “pollen” and “ovules”); 41:14-15 (“The plant part of claim 1, wherein the plant part is an ovule or pollen”)
Claims 3-4 and 12-13	18:20-28 (“F1 hybrids” sought as “commercial hybrids” because they “are more vigorous than their inbred parents”)
Claims 5, 14, and 19	18:67-19:1 (disclosing crossing “F1 hybrid” with “third inbred”)
Claims 6 and 15	34:22-26 (disclosing “[h]aploid induction systems” in which “haploid plants from any genotype” may be created “by crossing a selected variety (as female) with an inducer variety”)
Claims 7, 16, and 20	37:60-65 (“The seed of maize variety PH47K2, the plant produced from the seed, the hybrid maize plant produced from the crossing of the variety, hybrid seed, and various parts of the hybrid maize plant and transgenic versions of the foregoing, can be utilized for human food, livestock feed, and as a raw material in industry.”)

	Relevant Disclosures in Longenberger (EX1006)
Claim 8	18:67-19:1 (disclosing crossing “F1 hybrid” with “third inbred”); 41:22-25 (claim 5)
Claim 10	18:12-13 (“locus conversion of PH47K2 for herbicide tolerance”); 18:15-16 (“locus conversion for insect or disease resistance”); 19:45-51 (“PH47K2 represents a new base genetic variety into which a new locus may be introgressed”); 11:28-36 (“A locus conversion refers to plants within a variety that have been modified in a manner that retains the overall genetics of the variety and further comprises one or more loci with a specific desired trait, such as male sterility, insect resistance, disease resistance or herbicide tolerance or resistance.”); 42:11-17 (“locus conversion confers a property selected from the group consisting of male sterility, site-specific recombination, abiotic stress tolerance, altered phosphate, altered antioxidants, altered fatty acids, altered essential amino acids, altered carbohydrates, herbicide tolerance, insect resistance and disease resistance”)

	Relevant Disclosures in Longenberger (EX1006)
Claim 11	20:35-43 (“At least one, at least two or at least three and less than ten, less than nine, less than eight, less than seven, less than six, less than five or less than four locus conversions may be introduced into the plant by backcrossing, introgression or transformation to express the desired trait”)
Claim 18	11:34-36 (“Examples of single locus conversions include... transgenes”); 20:48-50 (“Transgenes transferred via backcrossing typically function as a dominant single gene trait and are relatively easy to classify.”); 26:4-32:37 (identifying particular types of transgenes)

D. Ground 3: Claims 1-20 Are Unpatentable as Obvious Over Hoffbeck (EX1007) and the Corresponding PVPA Certificate (EX1010)

136. Hoffbeck discloses PHH5G—a prior art inbred variety with properties very similar to those of the 1PFHC43 variety claimed in the ’020 Patent. Hoffbeck was not of record during prosecution even though its disclosures are highly similar to those in the ’020 Patent including the disclosure of the PHH5G variety having

similar characteristics to the characteristics to the 1PFHC43 variety, as explained herein at paragraphs 59, 66-75, 82, 141-145, and Appendix B.

137. Hoffbeck discloses that PHH5G can be used “to Develop Another Maize Plant” and in particular is a “source of breeding material that may be used to develop new maize inbred varieties.” EX1007, 30:29-35. It also discloses specific cross breeding techniques for producing such “new inbred” varieties. *Id.*, 2:52. In particular, Hoffbeck discloses using PHH5G to derive new maize seeds that are genetically and physically similar to PHH5G. EX1007, 30:29-31:43.

138. Consistent with these disclosures, PHH5G was previously used as one of the parents for at least six inbred and hybrid corn varieties. EX1061, U.S. Patent No. 9,596,820, 18:49-50; EX1062, U.S. Patent No. 8,598,433, 13:3-4; EX1063, U.S. Patent No. 8,319,014, 12:60-65; EX1064, U.S. Patent No. 8,273,948, 12:60-62; EX1065, U.S. Patent No. 8,252,989, 40:17-18; EX1066, U.S. Patent No. 8,148,616, 39:53-54.

139. As Hoffbeck itself discloses, POSAs would have had reason to use PHH5G as the starting point to create other inbred lines. The nature of the maize market confirms the reasons to create a wide array of new varieties using PHH5G as the starting point.

140. POSAs would have had a reasonable expectation of obtaining an inbred maize variety with PHH5G as a parent, particularly given (1) the routine

nature of the breeding techniques involved, (2) Hoffbeck's disclosure of preparing new inbred varieties (EX1007, 30:29-35), and (3) the previous instances already reported in which PHH5G had been used as a parent to obtain other lines.

1. Claim 1

141. Claim 1 encompasses a seed, plant part, or plant cell of variety 1PFHC43. 1PFHC43's disclosed characteristics are highly similar to PHH5G's as disclosed in Hoffbeck, and nothing in the '020 Patent's specification or otherwise in the intrinsic record suggests any property of 1PFHC43 that POSAs would have viewed as surprising or unexpected over PHH5G. *Supra* §IX.A.2.

142. Comparing the values disclosed in Hoffbeck against the 95% confidence intervals for the values disclosed in the '020 Patent shows that most of the values fall within the confidence interval. *See* Appendix B (green highlighting indicating values within range). This demonstrates that the differences for most measurements are likely not statistically significant. The only characteristics falling outside the 95% confidence interval are: tassel length and cob diameter. *See* Appendix B. However, there is no indication, even if these characteristics are physically different, that the differences have any meaning to the performance of the plant or have any commercial significance. Of course, it remains unclear the degree to which any difference may be due to difference in growing conditions and location for the samples. In any event, as discussed for the respective

characteristics at paragraphs 65-75, the values for 1PFHC43 all fall within or are similar to the ranges established by the prior art.

143. The record does not explain the significance of any differences between the claimed variety and known varieties. To the extent such differences exist, there is no basis from which to conclude they are significant or unexpected as compared to the 1PFHC43 variety disclosed in Hoffbeck and touted therein as a potential starting point for future inbred lines. Indeed, none of the differences have any material commercial significance. In particular, none of them are relevant to the underlying goal identified in the '020 Patent of developing “stable, high yielding maize varieties and hybrids that are agronomically sound with maximal yield over one or more different conditions and environments.” EX1001, 1:23-26. Nor are they relevant to the nature of the '020 Patent’s disclosed “Industrial Applicability.” EX1001, 36:49-37:26.

144. Again considering the three characteristics relied upon by the Examiner (see paragraph 101), I conclude that these features are not a basis to distinguish the '020 Patent’s 1PFHC43 from Hoffbeck for the following reasons:

- a. Grain Texture. 1PFHC43 and Hoffbeck’s PHH5G are both described as flint-dent. *See* paragraph 59.
- b. Row Alignment. 1PFHC43 and Hoffbeck’s PHH5G both have a row alignment of “2” or “slightly curved.” *See* paragraph 59.

c. Aleurone Color. 1PFHC43 is described as having a clear aleurone color, whereas Hoffbeck's PHH5G has a yellow aleurone color. *See* paragraph 59. As described above at paragraph 101, because 1PFHC43 has yellow endosperm and thus a product would also be yellow, the combination of yellow endosperm and clear aleurone for 1PFHC43 does not constitute a material difference over Hoffbeck's PHH5G variety with yellow endosperm and aleurone.

145. As discussed above at paragraphs 63-82, each of the characteristics shown in the '020 Patent, Table 1 is either within the range established by the prior art, is not technically or economically relevant, or both. Accordingly, claim 1 would have been obvious over Hoffbeck.

2. Claims 2-20

146. Claims 2-20 are likewise unpatentable as obvious over Hoffbeck for the same reasons detailed immediately above concerning claim 1 and for the additional reasons explained in §IX.B.2 concerning why claims 2-20 are obvious over Smalley and as further confirmed by PO's other prior art patents (EX1067-EX1071) including analogous claims related to other inbred corn lines. Hoffbeck has disclosures paralleling Challenged Claims 2-20 and/or disclosures in Smalley identified in §IX.B.2 concerning claims 2-20. In particular:

	Relevant Disclosures in Hoffbeck (EX1007)
Claim 2	8:61-64 (“plant part” includes “pollen” and “ovules”)
Claims 3 and 12	52:32-33 (“An F1 hybrid maize seed produced by crossing the plant of claim 3 with a different maize plant”)
Claims 4 and 13	52:32-33 (“An F1 hybrid maize seed produced by crossing the plant of claim 3 with a different maize plant.”)
Claims 5, 14, and 19	52:38-41 (“A method for developing a second maize plant in a maize plant breeding program comprising applying plant breeding techniques to a first maize plant, or parts thereof”)
Claims 6 and 15	45:31-35 (“A method for producing a second maize plant or plant part, the method comprising doubling haploid seed generated from a cross of the plant or plant part of claim 5 with an inducer variety, thereby producing the second maize plant or plant part.”)
Claims 7, 16, and 20	35:35-48 (“Maize is used as human food, livestock feed, and as raw material in industry. ...The maize wet-milling industry can provide maize starch, maize syrups, and dextrose for food use.

	Relevant Disclosures in Hoffbeck (EX1007)
	... non-grain portions of the [maize] plant, [are] also used extensively as livestock feed.”) ¹⁴
Claim 8	52:32-50 (“10. An F1 hybrid maize seed produced by crossing the plant of claim 3 with a different maize plant. 11. A maize plant produced by growing the F1 hybrid maize seed of claim 10. 14. A method for developing a second maize plant in a maize plant breeding program comprising applying plant breeding techniques to a first maize plant, or parts thereof, wherein said first maize plant is the plant of claim 11 and wherein application of said techniques results in development of said second maize plant.”)
Claims 9 and 17	Producing nucleic acid from the seed, plant, plant part, or plant cell of claim 1 was well known in the art. <i>See</i> EX1067, 44:42-44 (“method for producing nucleic acids, the method comprising isolating nucleic acids from the seed, plant, plant part, or plant cell of claim 1”); EX1072 , U.S. Patent No., 10,011,828,

¹⁴ Numerous prior art patents disclosed the specific list of “silage, starch, fat, syrup or protein” recited in claims 7, 16 and 20. *See*, e.g., EX1067-71.

	Relevant Disclosures in Hoffbeck (EX1007)
	Abstract (“isolating DNA from biological materials such as seeds”); EX1073, U.S. Patent No. 8,927,214, Title (“Method and compositions for dual extraction of protein and nucleic acid”).
Claim 10	15:33-34 (“locus conversion of PHH5G for herbicide tolerance”); 15:36-37 (“locus conversion for insect or disease resistance”); 18:21-24 (“The seed industry commonly markets “triple stacks” of base genetics; which can be varieties comprising a locus conversion of at least 3 loci.”); 17:39-46 (“A locus conversion of PHH5G will retain the genetic integrity of PHH5G. ... A locus conversion of PHH5G will comprise at least 92%, 93%, 94%, 95%, 96%, 97%, 98% or 99% of the base genetics of PHH5G.”); 18:6-15 (“Desired traits that may be transferred through backcross conversion include, but are not limited to, waxy starch, sterility (nuclear and cytoplasmic), fertility restoration, grain color (white), nutritional enhancements, drought resistance, enhanced nitrogen utilization efficiency, altered nitrogen responsiveness, altered fatty acid profile, increased digestibility,

	Relevant Disclosures in Hoffbeck (EX1007)
	low phytate, industrial enhancements, disease resistance, bacterial, fungal or viral), insect resistance, herbicide resistance and yield enhancements.”)
Claim 18	22:1-2 (“In some embodiments of the invention, a transformed variant of PHH5G may comprise at least one transgene”); 22:36-38 (“a backcrossing approach is commonly used to move a transgene from a transformed maize plant to an elite inbred variety, and the resulting progeny would then comprise the transgene(s)”); 18:47-49 (“Transgenes transferred via backcrossing typically function as a dominant single gene trait and are relatively easy to classify.”); 23:53-30:27 (identifying particular types of transgenes)

X. GROUND 4: CLAIMS 1-20 LACK SPECIFIC UTILITY

147. Claims 1-20 are unpatentable for the separate and independent reason that the claimed invention “lacks a specific and substantial utility” as required by §101. I describe in detail the basis for my opinion in this Section X. At a high

level, I reach this opinion because the utility described in the '020 Patent is lacking as compared to the stated purpose and use as well as the prior methods established by POSAs for describing utility.

148. Nothing in the '020 Patent's specification suggests any "specific benefit" provided by the claimed invention. Nothing in this particular patent's specification establishes that claims 1-20 are a "useful improvement" over earlier corn varieties.

149. Here, however, the '020 Patent only disclosed general uses for the 1PFHC43 variety, not specific utility that satisfies §101. The specification's "Industrial Applicability" section is essentially identical to that in Longenberger and very similar to those in Smalley and Hoffbeck. *See* EX1001, 36:49-37:26; EX1005, 34:1-37; EX1006, 37:21-65; EX1007, 35:33-36:3. Nothing in the record suggests any utility specific to the 1PFHC43 variety itself beyond that generic to any species of corn.

150. Likewise, to the extent the '020 Patent suggests particular phenotypical differences between the claimed 1PFHC43 variety and prior art varieties, it never even expressly identifies such differences—much less explains why they confer some specific benefit not already available from the prior art. Instead, as I previously noted, the relevant table ("Variety Description

Information”) is drawn essentially verbatim from a form prepared by the USDA and used in connection with PVPA certificates.

151. Nothing in the ’020 Patent suggests any reason why the claimed variety’s properties have such characteristics and the potential for significant utility. Any suggestion to that effect would instead necessarily flow from POSAs’ preexisting knowledge concerning corn in general rather than being based on the specification’s actual disclosures regarding the claimed variety in particular.

152. For example, if one assumed for the sake of analysis that the claimed variety’s length of ear node leaf (somewhat greater than the angles of the varieties disclosed in Smalley, Longenberger, and Hoffbeck, but within the range suggested by other preexisting inbred lines (see paragraph 70) somehow established the variety’s specific utility because POSAs would recognize some alleged benefit, such a conclusion would simply confirm the obviousness of claims. Achieving such phenotypical variations through breeding techniques was well within the level of ordinary skill in the art as of July 2021, though no utility is apparent.

153. I have reviewed the ’020 Patent with reference to the utility requirement of §101. I have concluded that the ’020 Patent does not disclose that the claimed subject matter has specific utility.

154. Given that the claimed maize variety is an inbred variety, POSAs would understand that any such utility would be in the form of generating

beneficial hybrids when crossed. This understanding is corroborated by the descriptions in the '020 Patent of the Combining Ability and Hybrid comparisons (EX1001,19:10-42) and the '020 Patent's description of Industrial Applicability (EX1001, 36:49-37:26). However, the patent shows no data on such characteristics, nor of performance on the very relevant traits described in the patent as genetic analysis-based selection criteria.

155. As explained above, the standard practice in the industry is for seed producers to develop inbred varieties that are crossed with other inbred varieties to yield a hybrid variety. That seed producer then sells the hybrid variety to farmers to be grown as an agricultural crop. Accordingly, with a limited exception I discuss below, it is the quality of the ultimate *hybrid* variety that is of the greatest interest to determining whether the inbred has value. A hybrid variety is judged by many characteristics, which include the yield, comparative relative maturity (CRM), disease resistance, quality of the corn grain for a particular purpose (e.g., food grade, milling, livestock feed, cellulose, fuel, etc.), and the like.

156. Characteristics to be improved by plant breeding include: yield, resistance to pests, seed composition, forage quality, tolerance to mineral stresses, tolerance to environmental stresses, adaptability to mechanization, standability (the ability to remain upright), stability of performance across years and locations, and

photoperiod response (the amount of light required by the variety). EX1016, Fehr at 2-7.

157. The partial exception to the value of the inbred variety being in the hybrid varieties, as discussed in the previous paragraph, is that there are certain breeding characteristics in the inbred variety that affect its ability to yield a good hybrid crop. These parental traits of an inbred line include, for example, the ability of the male plant to provide sufficient pollen, the yield potential of a female parent, and the ability of the female parent to produce high quality seed which maintains seed performance and viability. However, this is only a partial exception, because the ultimate goal is still to achieve a successful hybrid crop. Furthermore, even if parental traits of the inbred line were the objectives of the breeding program, the measured traits and asserted benefits (utility), as outlined above, would have been different than the trait values disclosed in Table 1 of the '020 Patent.

158. In addition to the normal commercial market of the company breeding the inbred line, there is also a market for selling/licensing inbred varieties to other seed producers. However, the value of the inbred variety on this market is also based on the same considerations as stated above, that is, the quality of the hybrid variety produced and quality of the inbred as a breeding stock, and not on the trait values described in Table 1 of the '020 Patent.

159. The upshot of the foregoing is that one needs actual data about the performance of the inbred variety based on its ability to be used as a parent to breed a hybrid with superior customer value and seed production traits in order to determine whether it has utility. A corn breeding program will most certainly generate any number of inbred varieties that are substantially useless if those lines cannot generate a good hybrid as judged by the commercial business and their customers.

160. I have carefully reviewed the '020 Patent to try to identify any disclosure showing that the claimed inbred variety has been shown to have utility for its intended purpose, i.e., as a parental line capable of breeding suitable hybrids. I do not see any such indication. The section on Industrial Applicability (36:49-37:26) describes ways in which corn may be used, but in no way ties the claimed inbred to any of these uses. Nor do the reported traits tie the claimed inbred to any of these uses. Moreover, the section appears identical to that of numerous other PHI patents as discussed above.

A. Analysis of Patents at Issue in *J.E.M. Ag Supply*

161. Counsel informs me that the 17 patents in the chart below were at issue in the case *J.E.M. Ag Supply, Inc. v. Pioneer Hi-Bred Int'l, Inc.* and that, in that case, the Supreme Court held that newly developed plant breeds were eligible

for utility patent protection if the claims satisfy all statutory requirements, including utility and non-obviousness. 534 U.S. 124, 127, 145 (2001).

162. A review of the patents at issued in *J.E.M.*, which were PHI's patents, shows that each included at least some comparisons, supported with data, between the claimed variety and earlier varieties.

163. For example, U.S. Patent No. 5,491,295 (EX1080, "Niebur," on which I am a co-inventor as discussed in Section II.C above), described Hybrid 3394 as "characterized by superior yield for maturity, excellent seedling vigor, very good roots and stalks, and exceptional stay green." EX1080, 2:66-3:3. Niebur included Example 1 comparing Hybrid 3394 with nine other hybrids, including six PHI hybrids and three from other suppliers. EX1080, 8:15-18:35. Among many other points of comparison, the Example 1 data showed that "[hybrid] 3394 has higher yield and grain harvest moisture, but lower test weight than [hybrid] 3503"; "[hybrid] 3394 has higher yield, grain harvest moisture, and test weight than [hybrid] 3417"; "[hybrid] 3394 is higher yielding but has lower grain moisture and test weight than [hybrid] 3398"; "[hybrid] 3394 outyields and has higher test weight but slightly lower grain moisture than [hybrid] 3379"; and so on with respect to the other comparators. EX1080, 8:18-54.

164. Niebur Example 2 provides strip test data comparing hybrid 3394 to the same six PHI hybrids and two of the three competitor hybrids used in Example

1. A strip test is a method for growing two or more varieties under substantially the same conditions so that data obtained for the varieties may be compared. The “strip” is a set of rows of a particular variety that is adjacent to a second strip with a second variety, and so on. Niebur describes a typical example in which strips of different hybrids were grown to obtain the comparative data presented in Niebur:

Comparison data was collected from strip tests that were grown by farmers. Each hybrid was grown in strips of 4, 6, 8, 12, etc. rows in fields depending on the size of the planter used. The data was collected from strip tests that had the hybrids in the same area and weighed. ... The number of comparisons represent the number of locations or replications for the two hybrids that were grown in the same field in close proximity and compared.

EX1080, 17:41-51. All of the other patents at issue in the *Pioneer v. J.E.M.* case also included strip test and/or other comparative data permitting direct comparisons. By contrast, the '020 Patent does not include any strip test data or other comparative information.

165. As summarized in Niebur, “[t]he results show Pioneer Brand Hybrid 3394 had a yield advantage over compared hybrids except Pioneer Hybrid 3398 where it had a disadvantage of 2.8 bushels per acre. 3394 had a slight moisture disadvantage against Pioneer Hybrids 3503, 3417, and 3362, and Garst Hybrid 8532. [Hybrid] 3394 showed a greater income advantage to the farmer based on adjusted gross income over all hybrids compared except Pioneer Hybrid 3398

where the disadvantage was \$4.18 per acre. With the exception of Pioneer Hybrid 3398, 3394's yield and income advantage plus its advantage for other characteristics over these hybrids will make it an important addition for most of the areas where these hybrids are grown." EX1080, 17:58-18:67.

166. Finally, in Example 3, Niebur included a comparison of key characteristics for the claimed hybrid 3394 as compared to the other six PHI hybrids and three competitor hybrids. EX1080, 19:58-21:39. In view of the data, Niebur concludes that "[hybrid] 3394 yielded well for its maturity, yielding equally well at both high and low plant population densities" and had "very good stay green and seedling vigor compared to the other hybrids." 20:65-21:1. In sum, "[hybrid] 3394 has overall excellent yield and agronomic characteristics which should make it an important hybrid in its area of adaptation." EX1080, 21:2-3.

167. Indeed, hybrid 3394 exhibited superior stay green as compared to hybrid 3398, which exceeded performance of hybrid 3394 in other categories. EX1080, Table 3 (showing STGR of 8 for 3384 compared to 3 for hybrid 3398); 5:10-14 (defining stay green ("STGR") as "the measure of plant health near the time of black layer formation (physiological maturity)"; "A high score indicates better late-season plant health...").

168. In short, the '295 Patent included data demonstrating that hybrid 3394 was superior in at least some significant characteristics as compared to other hybrids.

169. In another example, U.S. Patent No. 5,453,564 (EX1040, "Chapman"), discloses inbred corn line PHTE4. EX1078, Title. Chapman describes PHTE4 as a variety that "produces hybrids that are high yielding and flower early. PHTE4 hybrids have above average seedling vigor, test weight and staygreen. PHTE4 hybrids also have above average resistance to brittle stalks." EX1078, 7:13-16. Chapman discloses "the traits and characteristics of inbred corn line PHTE4 ... in comparison with other inbreds and in hybrid combination." EX1078, 9:62-65.

170. Chapman's Tables 3A-3E present comparisons between inbred line PHTE4, on the one hand, and inbred lines PHN15, PHNV4, PHJ40, PHT46, and PHBW8, respectively. EX1078, col. 11-16. From these data, Chapman concludes that "PHTE4 has lower yield and grain harvest moisture but higher test weight compared to PHN15"; "PHTE4 has lower yield and higher grain harvest moisture than PHNV4"; "PHTE4 has higher yield and grain harvest moisture but lower test weight compared to PHJ40"; "PHTE4 has a higher yield than PHT46"; "PHTE4 has lower yield and grain harvest moisture but higher test weight compared to PHBW8." EX1078, 9:67-10:26.

171. Chapman's Table 4A compares "PHNV4 to PHTE4 crossed to the same inbred testers"; Table 4B compares "PHNV4 to PHTE4 crossed to the same kinbred testers"; Table 4C compares "PHTE4 to PHBW8 crossed to the same kinbred testers." EX1078, col. 15-18. From this data, Chapman conclude that "[t]he PHTE4 hybrids have higher yield and grain harvest moisture" as well as "better seedling vigor and higher early stand count" when compared to the PHNV 4 hybrids, and higher grain harvest moisture and better seedling vigor than the PHRE1 hybrids. EX1078, 10:33-43.

172. Finally, Chapman's Tables 5A and 5B compare hybrids of PHTE4 to hybrids of PHBW8 and PHRE1, respectively. EX1078, col. 17-18. Chapman concludes that PHTE4 and PHBWB shows similar yield when test weight when crossed to the same inbred, but "[t]he PHTE4 hybrid is taller with higher ear placement compared to the PHBW8 hybrid." EX1078, 10:53-54. The "PHTE4 hybrid has significantly higher grain harvest moisture," better test weight, and lower ear placement than the PHRE1 hybrid. EX1078, 10:57-59.

173. Accordingly, Chapman discloses information showing that the claim PHNV4 was superior in at least some relevant respects.

174. Examples of disclosures for these and the other patents in the *J.E.M.* case are set forth in the following chart:

Hybrid	Patent No.	Notable Disclosures
3394	5,491,295 (EX1080)	“Hybrid Corn Plant & Seed” 2:66-3:3 (“This hybrid corn plant is characterized by superior yield for maturity, excellent seedling vigor, very good roots and stalks, and exceptional stay green. It is widely adapted, but performs best in the Central and Eastern Corn Belt.”) 4:50-55 (“defining “PERCENT WINS”: “For yield, moisture, income, populations, stand, roots, and test weight, it would be the percentage of comparisons that the hybrid to be patented yielded more, had lower harvest moisture percentage, had greater income per acre, had better stalks, had better roots, and had higher test weight, respectively, in strip tests.”) 5:36-45 (“Pioneer Brand Hybrid 3394 is a single cross, yellow endosperm, dent corn hybrid with

Hybrid	Patent No.	Notable Disclosures
		superior yield in its maturity. It has stable yield across environments, has above average grain appearance with average test weight, and has exceptional stay green. 3394 has excellent seedling vigor and very good drought tolerance. The inventor has observed that the leaf angle is semi upright and the leaf is short and wide, which is a unique characteristic of this hybrid. The hybrid has the potential to form an abscission layer and drop ears free from the husk.”) 8:15-18:35 (Example 1 – “Research Comparisons” of Hybrid 3394 against nine other hybrids—six from Pioneer and three from competitors) 17:40-20:55 (Example 2 – “Strip Test Data for Hybrid 3394 against nine other hybrids—six from Pioneer and three from competitors)

Hybrid	Patent No.	Notable Disclosures
		20:58-21:4 (Example 3 – “Comparison of Key Characteristics for Hybrid 3394...)
	5,506,367 (EX1083)	“Inbred Corn Line PHP38” 6:20-36 (“Inbred corn line PHP38 is a yellow, dent corn inbred that provides an acceptable male or female parental line in crosses for producing first generation F1 corn hybrids. PHP38 is best adapted to the central and eastern regions of the United States. Hybrids of PHP38 also possess very good drought tolerance and stability of yield which makes them extremely well-adapted for the hot, arid growing areas of the Western United States. The inbred can be used to produce hybrids from approximately 111-126 relative maturity based on the Minnesota Relative Maturity Rating System for harvest moisture of grain. PHP38 should make a good female since it

Hybrid	Patent No.	Notable Disclosures
		has acceptable yield, good early vigor, and good early stand establishment. PHP38 would also be acceptable as a male because of its pollen yield. The inbred in hybrid combination has excellent stay green and overall disease tolerance. PHP38 has excellent stalks and above average roots. PHP38 hybrids generally have very good grain quality and high test weight.”) 11:44-20:45 (“Inbred and Hybrid Performance of PHP38”)
	5,567,861 (EX1087)	“Inbred Corn Line PHN46” 6:7-16 (“Inbred corn line PHN46 is a yellow, dent corn inbred that provides an acceptable male parental line in crosses for producing first generation F1 corn hybrids. PHN46 is best adapted to the Central Corn Belt of the United States. The inbred can be used to produce hybrids from approximately 110-122 relative

Hybrid	Patent No.	Notable Disclosures
		maturity based on the Minnesota Relative Maturity Rating System for harvest moisture of grain. PHN46 should make an excellent male since it has high pollen yield. The inbred in hybrid combination has good yield, stay green, stalks, and roots.”) 9:63-24:40 (“Inbred and Hybrid Performance of PHN46”)
3489	5,557,035 (EX1086)	“Hybrid Corn Plant & Seed (3489)” 4:41-43 (“3489 is a very high yielding, widely adapted, stable 108 CRM hybrid. 3489 has above average yield across all environments.”) 7:24-38 (“Pioneer Brand Hybrid 3489 has exceptional yield for its maturity. The hybrid is widely adapted and very stable which will make

Hybrid	Patent No.	Notable Disclosures
		it an excellent companion hybrid to many of the hybrids in its area of adaptation....It has had top yield for four straight years beginning with very early experimental topcross testing. Compared to the closest existing hybrid (3417), 3489 has resistance to brittle stalk, resistance to heavy infection of common rust, tolerance to less solar radiation and the ability to withstand excessive wet soil conditions.”)
	5,444,178 (EX1077)	“Inbred Corn Line PHHB” 7:16-26 (“PHHB4 brings together more yield in hybrids than either parental line. In hybrid combination PHHB4 has desirable plant and ear height, resistance to brittle stalk, and resistance to common rust. Hybrids of PHHB4 do well in both dry and wet years compared to the closest prior art, but are especially better in wet years. Inbred corn line PHHB4 is a yellow, dent corn inbred

Hybrid	Patent No.	Notable Disclosures
		and provides an acceptable female parental line in crosses for producing first generation F1 corn hybrids. PHHB4 is adapted to most regions of the United States but does best in Nebraska, Iowa, Illinois and Indiana.”) 9:44-16:53 (“Examples – Inbred and Hybrid Performance of PHHB4”)
	5,633,427 (EX1089)	“Inbred Corn Line PHHB” [Continuation of the ’178]
	5,347,081 (EX1076)	“Inbred Corn Line PHK56” 6:10-20 (“PHK56 is best adapted to the Central Corn Belt of the United States. The inbred can be used to produce hybrids from approximately 106-118 relative maturity based on the Minnesota Relative Maturity Rating System for harvest moisture of grain. PHK56 would make a good

Hybrid	Patent No.	Notable Disclosures
		male because it is a good pollinator with good pollen yield. In hybrid combinations PHK56 provides high yields, has low grain moisture at maturity and performs under stress as well as good conditions. It also has good roots, low ear placement, and gray leaf spot tolerance.”) 9:63-12:20 (examples concerning PHK56’s “inbred and hybrid performance”: “These results show that PHK56 hybrids offer significant advantage over commercial products that are sold for yield and other important agronomic traits.”)
3559	5,453,564 (EX1078)	“Inbred Corn Line PHTE4” 7:13-16 (“PHTE4 produces hybrids that are high yielding and flower early. PHTE4 hybrids have above average seedling vigor, test weight and

Hybrid	Patent No.	Notable Disclosures
		staygreen. PHTE4 hybrids also have above average resistance to brittle stalks.”) 9:60-10:62 (“In the examples that follow, the traits and characteristics of inbred corn line PHTE4 are given as a line in comparison with other inbreds and in hybrid combination.”)
	5,495,069 (EX1081)	[Continuation of the ’564]
	5,569,822 (EX1088)	[Continuation of the ’069]
	5,534,661 (EX1084)	“Inbred Corn Line PHKW3” 13:46-24:15 (“In the examples that follow, the traits and characteristics of inbred maize line PHKW3 are given as a line in comparison with other inbreds and in hybrid combination....”) See, e.g., 13:52-14:6 (disclosing data indicating that claimed PHKW3 was “taller,” had “higher

Hybrid	Patent No.	Notable Disclosures
		ear placement,” and had “significantly lower grain harvest moisture” as compared to either parent).
3730	5,689,036 (EX1091)	“Hybrid Maize Plant and Seed (3730)” 5:32-36 (“This hybrid maize plant is characterized by high yield, strong stalks, excellent early season growth and rapid dry-down after reaching maturity. It is best adapted for the North Central Region of the United States.”) 10:38-44 (“Hybrid 3730 demonstrates an unexpected, excellent early season growth that is very rapid relative to other hybrids for its maturity. In addition, Hybrid 3730 has very good stalks and rapid dry-down after reaching maturity. Hybrid 3730 also demonstrates improved staygreen over other hybrids in its maturity.”)

Hybrid	Patent No.	Notable Disclosures
		12:25-16:67 (“Research Comparisons” against hybrids 3723, 3733, 3714, and 3563) 17:1-25 (“Strip Test Data for Hybrid 3730 against five other hybrids: “Hybrid 3730 has a yield advantage over all of the hybrids. Hybrid 3730 has an income/acre advantage over all but one of the hybrids, 3723, which has a similar income per acre as 3730. The income per acre advantage ranged from \$3.46 to \$13.80. Hybrid 3730’s yield and income advantage plus its advantage for other characteristics over these hybrids will make it an important addition for most of the areas where these hybrids are grown.”) 18:1-25 (“Comparison of Key Characteristics for Hybrid 3730: “Hybrid 3730 has good drydown and early growth when compared to the other

Hybrid	Patent No.	Notable Disclosures
		hybrids. Hybrid 3730 has overall high yield and other good agronomic characteristics which should make it an important hybrid in its area of adaptation.”)
	5,545,813 (EX1085)	“Inbred Maize Line PHRF5” 9:59-10:2 (“Inbred maize line PHRF5 is a yellow, dent maize inbred that is best suited as a female in crosses for producing first generation F1 maize hybrids. Inbred maize line PHRF5 is best adapted to the North Central region of the United States and can be used to produce hybrids from approximately 99 relative maturity based on the Comparative Relative Maturity Rating System for harvest moisture of grain. Inbred maize line PHRF5 yields well for its maturity, has good stalks and good roots. Inbred maize line PHRF5 has good early season growth and good staygreen. Although PHRF5 has a somewhat

Hybrid	Patent No.	Notable Disclosures
		lower resistance to Brittle Snap than other inbreds, PHRF5 demonstrates good stalk lodging resistance.”) 13:5-22:59 (providing “performance examples of PHRF5,” including performance of hybrids)
34R06	5,557,035 (EX1086)	[covered above]
	5,444,178 (EX1077)	[covered above]
	5,633,427 (EX1089)	[covered above]
	5,347,081 (EX1076)	[covered above]
35N05	5,502,272 (EX1082)	“Hybrid Corn Plant and Seed (3563)”

Hybrid	Patent No.	Notable Disclosures
		Abstract (“This hybrid corn plant is characterized by excellent yield potential, good test weight, and fast drydown. It performs best from Indiana/Ohio West.”) 8:5-14:28 (Example 1—“Research Comparisons” between 3563 and three other Pioneer hybrids along with one DeKalb hybrid) 13:29-16:20 (Example 2—“Test Strip Data” comparison between 3563 and three other Pioneer hybrids along with one DeKalb hybrid) 15:22-47 (“Comparison of Key Characteristics for Hybrid 3563....Relative to the hybrids compared, <i>3563 has higher test weight and better grain appearance.</i>”)
	5,463,173 (EX1079)	“Inbred line PHR61”

Hybrid	Patent No.	Notable Disclosures
		5:63-66 (“Inbred corn line PHR61 is a yellow, dent corn inbred that is best used as a female in crosses for producing first generation F1 corn hybrids. PHR61 is best adapted to the North Central Region of the United States.”) 6:2-14 (“PHR61 has consistent high hybrid yields for its grain moisture maturity. PHR61 has excellent stalks, stay green, and grain quality... Inbred PHR61 provides hybrids which, although adapted to cool Northern climates, perform exceptionally well in warm growing seasons which occasionally occur in the Northern Corn Belt of the United States. 9:55-11:1 (“Inbred and Hybrid Performance of PHR61” as compared to six other Pioneer inbred lines)

Hybrid	Patent No.	Notable Disclosures
	5,347,081 (EX1076)	[covered above]
34K77	5,534,661 (EX1084)	[covered above]
35R57	5,689,034 (EX1090)	“Inbred Maize Line PH24E” 9:55-10:9 (“Inbred maize line PH24E is a yellow, dent maize inbred that is best suited as either a male or female in crosses for producing first generation F1 maize hybrids. Inbred maize line PH24E is best adapted to the Northcentral region of the United States and can be used to produce hybrids from approximately 106 relative maturity based on the Comparative Relative Maturity Rating System for harvest moisture of grain. As an inbred per se, maize line PH24E is a high yielding female with a resistance to barrenness.

Hybrid	Patent No.	Notable Disclosures
		Inbred PH24E exhibits good cold test results, good stalks and dark green plants. As an inbred per se, PH24E exhibits excellent resistance to barrenness which makes it a reliable seed production parent. Inbred PH24E demonstrates excellent general combining ability. When in hybrid combination, PH24E exhibits high yield for its maturity with a stability over different environments across the Northcentral Corn Belt. PH24E hybrids have excellent roots, good stalk strength and quality and short plant stature. PH24E hybrids' short plant stature and associated reduced crop residues, make them well adapted to conservation tillage cropping systems. PH24E hybrids perform well from the eastern to western edges of the Northcentral Corn Belt.”) 13:1-26:30 (“Performance Examples of PH24E,” including hybrid performance”).

Hybrid	Patent No.	Notable Disclosures
3563	5,502,272 (EX1082)	[covered above]
	5,463,173 (EX1079)	[covered above]
	5,347,081 (EX1076)	[covered above]
3751	5,082,992 (EX1075)	“Inbred Corn Line PHP02” 4:66-5:1 (“Inbred corn line PHP02 is a yellow dent corn inbred that gives superior characteristics in hybrid combination and is an excellent parental line in crosses for producing first generation F1 corn hybrids.”) 5:21-25 (“The inbred is adapted over a wide area of the northern Corn Belt and can be used advantageously in hybrids from approximately

Hybrid	Patent No.	Notable Disclosures
		95-114 RM based on the Minnesota Relative Maturity Rating System for harvest moisture of the grain.”)

175. These disclosures in the patents at issue in the *J.E.M.* case identified particular reasons why the claimed varieties had specific value separate and apart from other corn varieties. In fact, during the *J.E.M.* case, the U.S. Patent Office signed a legal brief stressing that the patents at issue (including my own patent) disclosed “readily identifiable benefits to farmers.” EX1030, 28. I agree with the Patent Office’s characterization.

176. By contrast, the ’020 Patent does not identify any such specific value or benefit to farmers.

XI. CONCLUSION

177. As explained above, the Challenged Claims of the ’020 Patent are rendered obvious by the combinations discussed above and the Challenged Claims are unpatentable under 35 U.S.C. § 103.

178. The Challenged Claims of the ’020 Patent lack specific utility and are therefore unpatentable under 35 U.S.C. § 101.

179. In signing this declaration, I understand that the declaration will be filed as evidence in a review proceeding before the Patent Trial and Appeal Board of the U.S. Patent and Trademark Office. I acknowledge that I may be subject to cross examination in the case and that cross examination will take place within the United States. If cross examination is required of me, I will appear for cross examination within the United States during the time allotted for cross examination.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of the Title 18 of the United States Code and that such willful false statements may jeopardize the results of these proceedings.

Executed on: 03/06/2024


Raymond D. Riley, Ph.D.

APPENDIX A

APPENDIX A MATERIALS CONSIDERED

Exhibit	Description
1001	U.S. Patent No. 11,666,020
1005	U.S. Patent No. 8,759,636 (“Smalley”)
1006	U.S. Patent No. 10,681,888 (“Longenberger”)
1007	U.S. Patent No. 7,528,307 (“Hoffbeck”)
1008	Plant Variety Protection Certificate No. 201200313
1009	Plant Variety Protection Certificate No. 202200416
1010	Plant Variety Protection Certificate No. 200700315
1011	Lundmark, C. Genetically Modified Maize. <i>BioScience</i> 2007, 57, 996
1012	Lee, E.A.; Tracy, W.F. <i>Modern Maize Breeding</i> , in Handbook of Maize: Genetics and Genomics; Bennetzen, J.L., Hake, S., Eds.; Springer: New York, NY, USA, 2009; pp. 141–160. ISBN 978-0-387-77863-1
1013	Byerlee, D., <i>The Globalization of Hybrid Maize, 1921–1970</i> . <i>J. Glob. Hist.</i> , 15:101–122 (2020)
1015	Andorf et al., <i>Technological advances in maize breeding: past, present and future</i> , <i>Theor Appl Genet.</i> , 132(3):817-849 (2019)
1016	Fehr et al., <i>Principles of Cultivar Development</i> (1987)
1017	Wych et al., <i>Production of Hybrid Seed, Corn and Corn Improvement</i> , Chapter 9 (1988)
1018	Schnable et al., The B73 Maize Genome: Complexity, Diversity, and Dynamics, <i>Science</i> , 326:1112-1115 (2009)
1019	“A Brief History of Corn – From Domestication to 1995,” Pioneer Hi-Bred International, Inc. (Dec. 19, 2022), https://www.pioneer.com/us/agronomy/domestication-of-corn.html
1020	Geiger, <i>Doubled Haploids in Hybrid Maize Breeding</i> , <i>Maydica</i> 54:485-99 (2009)
1021	Weber, <i>Today’s Use of Haploids in Corn Plant Breeding</i> in <i>Advances in Agronomy</i> , Volume 123 (2014)
1030	Brief for the United States as Amicus Curiae Supporting Respondent, <i>J.E.M. AG Supply, Inc. v. Pioneer Hi-Bred Int’l, Inc.</i> , 534 U.S. 124 (2001) (No. 99-1996) (filed June 2001)
1034	Excerpts from Merriam-Webster’s Collegiate Dictionary (11th ed. 2006)
1035	Altman, <i>Standard deviations and standard errors</i> , <i>Brit. Med. J.</i> , 331:903 (2005)
1036	U.S. Patent No. 9,848,573
1037	U.S. Patent No. 10,154,640
1038	U.S. Patent No. 10,165,747

1039	U.S. Patent No. 10,653,094
1040	U.S. Patent No. 6,252,148
1041	U.S. Patent No. 10,827,697
1042	U.S. Patent No. 10,869,445
1043	U.S. Patent No. 11,696,545
1044	U.S. Patent No. 8,772,608
1045	U.S. Patent No. 8,872,005
1046	U.S. Patent No. 8,895,820
1047	U.S. Patent No. 8,927,829
1048	U.S. Patent No. 8,946,508
1049	U.S. Patent No. 9,078,408
1050	U.S. Patent No. 9,084,402
1051	U.S. Patent No. 9,204,604
1052	U.S. Patent No. 9,370,158
1053	U.S. Patent No. 9,814,197
1054	U.S. Patent No. 9,861,059
1059	U.S. Patent Publication No. 2005/0257298
1060	U.S. Patent No. 10,863,705
1061	U.S. Patent No. 9,596,820
1062	U.S. Patent No. 8,598,433
1063	U.S. Patent No. 8,319,014
1064	U.S. Patent No. 8,273,948
1065	U.S. Patent No. 8,252,989
1066	U.S. Patent No. 8,148,616
1067	U.S. Patent No. 10,492,410
1068	U.S. Patent No. 10,492,411
1069	U.S. Patent No. 10,492,412
1070	U.S. Patent No. 10,492,413
1071	U.S. Patent No. 10,492,414
1072	U.S. Patent No. 10,011,828
1073	U.S. Patent No. 8,927,214
1075	U.S. Patent No. 5,082,992
1076	U.S. Patent No. 5,347,081
1077	U.S. Patent No. 5,444,178
1078	U.S. Patent No. 5,453,564
1079	U.S. Patent No. 5,463,173
1080	U.S. Patent No. 5,491,295
1081	U.S. Patent No. 5,495,069
1082	U.S. Patent No. 5,502,272

1083	U.S. Patent No. 5,506,367
1084	U.S. Patent No. 5,534,661
1085	U.S. Patent No. 5,545,813
1086	U.S. Patent No. 5,557,035
1087	U.S. Patent No. 5,567,861
1088	U.S. Patent No. 5,569,822
1089	U.S. Patent No. 5,633,427
1090	U.S. Patent No. 5,689,034
1091	U.S. Patent No. 5,689,036
1092	U.S. Patent No. 5,159,133
1093	Comparison between EX1001 ('020 Patent) and EX1006 (Longenberger)

APPENDIX B

Appendix B

	US Patent No. 11,666,020			
	Variety: 1PFHV43			
	95% CI			
	Value	SE	Low CI	High CI
PLANT:				
Plant height (to tassel tip) (cm), mean (SE)	209.3	9.26	191.2	227.4
Ear height (to base of top ear node) (cm), mean (SE)	72	6	60.2	83.8
Length of Top Ear Internode (cm), mean (SE)	13.6	1.43	10.8	16.4
Number of Nodes Above Ground, mean (SE)	13.3	1.1	11.1	15.5
LEAF:				
Width of Ear Node Leaf (cm), mean (SE)	8.1	0.62	6.9	9.3
Length of Ear Node Leaf (cm), mean (SE)	87.2	2.84	81.6	92.8
Number of Leaves Above Top Ear, mean (SE)	6.2	0.73	4.8	7.6
Leaf Angle (degrees) (at anthesis, 2nd leaf above top ear to the stalk), mean (SE)	29.8	7.33	15.4	44.2
TASSEL:				
Number of Primary Lateral Branches, mean (SE)	3	1.47	0.1	5.9
Branch Angle from Central Spike (degrees), mean (SE)	27	10.77	5.9	48.1
Tassel Length (from peduncle node to tassel tip) (cm), mean (SE)	60.3	3.45	53.5	67.1
Peduncle Length (from top leaf node to lower branch) (cm), mean (SE)	25.2	3.17	19.0	31.4
Central Spike Length (cm), mean (SE)	30.6	3.71	23.3	37.9
EAR (Unhusked ear):				
Flag Leaf Length (cm) (from flag leaf collar to tassel tip), mean (SE)	45.3	3.32	38.8	51.8
Length of Interior Husk (cm), mean (SE)	21.1	1.8	17.6	24.6
EAR (Husked ear data):				
Shank Length (cm), mean (SE)	6.7	1.66	3.4	10.0
Ear Length (cm), mean (SE)	16.5	2.29	12.0	21.0
Ear Diameter at mid-point (mm), mean (SE)	43.6	1.38	40.9	46.3
Ear Weight (gm), mean (SE)	149.7	26.81	97.2	202.2
Number of Kernel Rows, mean (SE)	15.6	0.99	13.7	17.5
Number of Kernels Per Row, mean (SE)	30.9	6.09	19.0	42.8
KERNEL (Dried):				
Kernel Length (mm), mean (SE)	11.7	0.88	10.0	13.4
Kernel Width (mm), mean (SE)	8	0.6	6.8	9.2
COB:				
Cob Diameter at mid-point (mm), mean (SE)	27.2	1.42	24.4	30.0

US Patent No. 8,759,636 (Smalley)			
Variety: PH1D84			
95% CI			
Value	SE	Low CI	High CI
179.5	1.47	176.62	182.38
58.4	1.24	55.97	60.83
14.7	0.22	14.27	15.13
N/D			
8.5	0.1	8.30	8.70
80	0.54	78.94	81.06
5.8	0.09	5.62	5.98
22.9	0.64	21.65	24.15
3.1	0.24	2.63	3.57
32.4	1.27	29.91	34.89
54.7	0.6	53.52	55.88
25.1	0.46	24.20	26.00
N/D			
N/D			
N/D			
6.4	0.31	5.79	7.01
13.5	0.2	13.11	13.89
36.3	0.35	35.61	36.99
85.7	3.06	79.70	91.70
13	0.24	12.53	13.47
N/D			
11.2	0.12	10.96	11.44
8.5	0.11	8.28	8.72
21.1	0.21	20.69	21.51

U.S. 10,681,888
Longenberger
(PH47K2)
Value
207
75.1
16.7
11.9
9.3
83.9
5.9
26.3
1.5
38.9
56.5
21.3
30.9
36.4
20.2
8.9
17
36.1
107.8
14
25.4
8.7
7.5
20.3

U.S. 7,528,307
Hoffbeck
(PHH5G)
Value
214.5
72
16.3
N/D
8.6
74.4
7.5
25.4
1.1
11.3
48.7
21.3
N/D
N/D
N/D
6.7
16.7
42.9
142.3
16.7
N/D
11.1
8
23.1