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The Evolution of Patenting Plants

The landscape of global food production has changed dramatically within the last hundred years. In addition to feeding a world population which has more than tripled, and perhaps in response to that change, agriculture has become more industrialized. Deemed the "Green revolution," farms have come to grow standardized crops that are more productive by using herbicides, pesticides and other chemicals. While this system has, arguably, done very well in feeding the world, the population continues to grow. If the world population continues to grow, UN estimates are that it will reach 9.1 billion by 2050. In order to feed everyone, some argue that agricultural land will need to become even more productive than it currently is. Given the environmental problems caused by the use of extensive chemical additives in agriculture, many believe that increasing production using traditional means is not possible. Some scientists, farmers, and politicians suggest that a second agricultural revolution is on the horizon: the use of genetically modified crops. Although many valid points support the use of genetically modified crops on a widespread basis, there are many facets of genetic modification which must be examined to evaluate whether this technology is the best solution to the problem of feeding an expanding world population. This discussion must include evaluating the way that these inventions are patentable and the effects this has on access to new inventions and ideas.

The very techniques used to create crops that produce a greater yield, whether it be through increased plant production, pest resistance, or varieties that are better able to grow in a variety of locations, have changed greatly in the post World War II era. Previously, farmers would develop crops well suited to their particular geographic location by using selective breeding, a technique used by plant breeders and farmers to modify the progeny, or offspring, of the crop. The process alters which traits are exhibited in subsequent generations by allowing only the plants with a desired trait to breed. This can be done by eliminating plants without the desired trait, by selectively saving seeds from plants that exhibit the desired trait, or by manually cross pollinating two plants that express the desired trait[i]. Selective breeding is time and labor intensive, given that the expression of a particular trait may depend upon several different genes or on the interaction of multiple genes. There are so many genetic combinations in a new generation of plants that it is almost impossible to control which progeny will grow. It is only through several rounds of selections that the plants will come to contain only those genes which produce the desired trait. Making multiple selections is a process that takes several seasons.

Farmers undertake this process in order to perfect their crops and produce more food and yet, prior to 1930 had no promise of a reward. At that time, farmers and plant breeders had no way to profit from making a new plant variety besides selling an improved plant product or greater amounts of the plant's products or seeds. Though the United States Constitution provided a patent system to reward inventors in other areas, plant breeders were unable to claim similar rewards. The patent system creates ownership by granting exclusive rights to make, use, and sell an invention to the individual who created it. In order for the government to give an inventor a patent on his or her invention, it must meet three requirements; novelty, usefulness, and non-obviousness. While utility and non-obviousness are important qualities in the determination of granting a patent, they do not constitute personal property rights in the same way as the novelty clause. This clause ensures that an inventor is only allowed to patent something that did not exist previously, so that someone cannot profit off of another's previous work[ii]. Before 1930, plant breeders were unable to obtain patents on their newly created plant varieties and maintain rights to the progeny created through that variety, even though the varieties were novel, useful, and the result of hard work.

Plant Patent Act of 1930

The Plant Patent Act of 1930 intended to give plant breeders similar rights to those of other inventors. The Senate gave several reasons for deeming this limited monopoly necessary: agriculture needed to be on equal economic footing with industry, plant breeding depended primarily on Government Funds and research stations, and this bill would provide plant breeders additional incentive to develop new varieties without government funds.[iii] From the account given by the Senate, it is apparent that this bill aimed to allow the plant breeder to reap the rewards of his hard work and also to generate an industry around the development of new plant varieties. With this bill, plant breeding, which had previously existed under the umbrella of government research, moved into the private sphere of development. The government recognized the national significance of having new varieties of food, medicinal plants, and plants deemed to be economically useful (such as rubber)[iv] and wanted to continue advancement in innovation. They believed that granting plant patents was the best way to go about it.

However, many guidelines limited what could be patented under the Plant Patent Act of 1930. Patentable plants had to constitute new and distinct varieties of plants clearly distinguishable from other varieties. New varieties could be generated from sports[v], mutants, or hybrids as long as they were asexually reproduced. The asexual reproduction of plants includes the processes of grafting, budding, cuttings, layering, or division to create a genetically identical plant. Reproduction in this manner ensures that the identity of the plant remains identical in each subsequent generation; there can be no change to the variety while reproducing it. But, the plants granted protection under this act cannot be "tuber-propagated." This is to say that they may not be the type of plant that, when asexually reproduced, is reproduced by the part of the plant used as food. Thus, plants that are reproduced through sexual reproduction and by seeds,[vi] as well as those solely reproduced by tubers, are not eligible for protection under this act. These stipulations severely limit the number of plants that can patented. Furthermore, the benefits of protection only extend to the right to propagate a new variety, not to control the plant once it is sold.

Plant Variety Protection Act of 1970

The Plant Variety Protection Act of 1970 considerably expanded the protection granted to plant breeders for new varieties. Rather than continuing to grant protection on the basis of patents, protection was given in the form of certificates of "plant variety protection" through a newly created Plant Variety Protection Office. The claims functioned as a patent, with similar length and depth of protection, but were no longer dealt with by the Patent and Trademark office. The Senate passed this Act with the intent of promoting the development of new plant varieties, encouraging private investment in plant breeding, giving farmers better varieties of plants and making American agricultural products competitive in world markets.[vii] These reasons mirror those given for the development of Plant Patent act 40 years prior. Even though this Act had the effect of expanding what plant varieties could be protected, it still maintained some important limitations. Sexually reproduced varieties were added to the list of protectable plants. Yet, carrots, celery, cucumbers, okra, peppers and tomatoes were excluded, as were first generation hybrids like corn. Despite the great expansion of plant protection that occurred as a result of including sexually reproduced varieties, the Act still limited the amount of control that breeders had over what users of these plants could do with them. Farmers could save and reuse protected seeds and could sell small amounts of the seed to other farmers; they had rights to use the plants and seeds that they had purchased again and again. This exception allowed the longtime tradition of seed saving to continue. Plant breeders could use protected varieties of plants to develop new patentable varieties.[viii] Thus, those who wanted to make improvements on the improvements could not only do so but had incentive to do so because they could protect their new varieties.

Diamond v. Chakrabarty

The Diamond v. Chakrabarty case was a pivotal case in the development of patenting living organisms and instrumental in the eventual patenting of genetically modified organisms. The case occurred when the scientist Ananda Chakrabarty developed a new type of bacteria by inserting the plasmids of several different bacteria into one. This technique predated the use of recombinant DNA technology, the process used to create genetically modified organisms, which will be further described in the following section. In the Chakrabarty invention, the new type of bacteria was created by taking pieces of extra chromosomal DNA, called plasmids, out of the donor bacteria and inserting them into the host bacterium. While this entailed moving genetic information from one organism to another, it did not use the chromosomal structures of DNA, it only used just those pieces of DNA loose within the cell body capable of reproducing themselves.

When the plasmids were inserted into the host bacteria, the combination of DNA enabled it to break down crude oil better than other bacteria. It seemed to squarely fit the criteria for a utility patent except for the fact that it was a living organism. It was a new organism that had a use, given the crude oil spills of the 1970's, and one that was non-obvious. Under patent law at the time, utility patents could not be given to living organisms because they were considered to be a product of nature and, as such, constituted a discovery rather than an invention. Many appeals after the initial rejection of the patent, the courts decided that the fact that the organism was living was inconsequential to its eligibility for a patent. They argued that because the bacterium had new man- made features that were not found in the "natural" functioning of the bacteria that it was patentable. They opened the floodgates of patentability when they suggested that patents are applicable for "anything under the sun that is made by man"[ix] in their ruling.

This ruling paved the way for genetically modified organisms to be patented when the technology for these alterations emerged just a few years after this ruling. It was a landmark case in determining the patentability of a living organism and made the case for patenting of life forms above and beyond bacteria, as long as the other qualifications for utility patents were met.

The next big change in establishing rights to new plant varieties came largely as a result of their development from a new technology. The development of recombinant DNA technology in the 1970's led to the invention of the genetically modified plants. Today, plants made using this technique are categorized differently under patent law: thus, a familiarity with how they are made becomes important to understanding the distinction. This next section will explain the biology behind genetic modification.

Genetic Modification: The Process and Results

Genetically modified organisms are made by inserting a piece of DNA from one organism into another. The process, while ultimately very simple, has many small steps that make it more complex than the overall simplicity of ideas might indicate. The account given here covers the basic steps of the genetic modification process. DNA, which is short for deoxyribonucleic acid, is a long chain of molecules that contains the genetic "information" of an organism. Each subunit of DNA is called a "nucleotide" and is made of a phosphate, a sugar called deoxyribose, and four nitrogenous bases: adenine, thymine, guanine, and cytosine and which are abbreviated as A, T, G, and C. Each deoxyribonucleotide contains one of these bases, and thus there are four different deoxyribonucleotides, from now on abbreviated simply with A, T, G, or C.

It is the combination of A's, T's, G's and C's that determines which proteins are coded for. A particular section of DNA may code for the production of one particular protein and is in that case called a gene. A gene is used as a template to synthesize a complementary RNA strand which is then used as a set of instructions for making the appropriate protein. A messenger RNA, or mRNA, takes efficient and slightly altered instructions from the DNA (which is in the nucleus of the cell) to the cytoplasm (outside the nucleus), where the cell manufactures the required protein. Thus, the combination of DNA and RNA molecules can be thought of as an instruction manual for making proteins. The proteins made using this information work together to build, operate and maintain an organism. Proteins thus both create the physical structure of the organism as well as regulate its function on a cellular level.

DNA is double stranded, meaning that it has two chains of molecules. Each strand is a sequence of A's, T's, G's, and C's, but because A's bond to T's and G's bond to C's, the rows are complementary. A DNA molecule can be represented as follows:

3'-ATTGAATCCATGGCGTAATGCCTGA-5'

5'-TAACTTAGGTACCGCATTACGGACT-3'

This diagram shows the complementary strands as they are aligned physically. The diagram only represents one microscopic section of DNA. While the number of base pairs in any given organism varies, plants on average have about 120,000,000 base pairs of information. That means that there are about 120 million different nucleotides in one plant DNA molecule.[x]

Several things are needed to make a genetically modified organism. In order to transfer DNA from one organism to another, a genetic engineer must have a piece of DNA that is of interest, which is typically the sequence for a gene that codes for a particular protein and thus a particular set of characteristics. This piece of DNA must be identified out of the entire genetic sequence and its function known. A tool to transfer the DNA with, called a vector, must be identified. Lastly, the host organism must be known and the desired outcomes for that organism identified.

Using the DNA of interest, the vector, and the host DNA, the process of genetic modification begins. First, the particular piece of DNA that is of interest is isolated and "cut" out of the entire DNA sequence. This is done by adding a site specific restriction enzyme to the DNA sample. The site specific restriction enzyme identifies a particular sequence of base pairs, which ideally are those located at the beginning and end of the desired sequence of DNA, and "cuts" it. Cutting the DNA involves breaking the bonds of the double stranded DNA at a particular place. The cleavage often leaves single stranded ends at each end of the DNA fragment which makes it easier to insert the desired DNA sequence into the vector. If we were to use a restriction enzyme on the representation of the double stranded DNA section provided above, we might end up with segments resembling the following:

3'-ATT**G** **AATTC**CATGGCGTAATGCCTGA-5'

5'-TAA**CTTAA** **G**GTACCGCATTACGGACT-3'

The restriction enzyme would locate the section of base pairs that are highlighted, GAATTC in this example, and its complementary CTTAAG, and cut between G and A. The vector, which is most often a strand of DNA, must also be "cut" with the same restriction enzyme so that the ends of the created pieces can "stick" together. "Sticking together" refers to the formation of bonds between the complementary base pairs, the source of which are the single stranded ends created by the restriction enzyme.

Before the vector's DNA can be cut open to allow for the insertion of the donor DNA, an appropriate vector, or tool for transfer, must be selected. Vectors often vary depending upon the size of the sample of DNA that they are expected to carry, whether or not their DNA has unique restriction sites for the restriction enzymes to cut, and the vector's own mechanisms of transferring the DNA into the host. Most often, the vector is the DNA of a type of bacteria that naturally infects its victims by inserting its own DNA into the host. Ingeniously using this natural capability, the genetic engineer inserts the DNA of interest into a vector which then inserts it into the desired host.

When genetically modifying plants, the bacteria *Agrobacterium tumefaciens* is often used as a vector. In unaltered settings, this plant pest creates tumors in plants by inserting its own DNA into the plant's DNA. By inserting its own DNA, the bacteria uses the host's own natural mechanisms of cell reproduction so that the DNA that has been inserted by the bacteria is reproduced in every subsequent cell that the original cell or cells infected by the bacteria produce. Thus, the plant can quickly come to produce the inserted DNA for itself and display the desired trait. The desired trait is expressed when the proteins that the inserted section of DNA codes for are produced. Genetic engineers harness the natural capabilities of the bacteria by first identifying the section of DNA that the vector inserts into its host. In the case of *A. tumefaciens*, engineers use that what they call the TI plasmid from this bacteria. They insert the DNA of interest into a section of the TI plasmid which is called the TDNA, the section of DNA that gets inserted into the host. Therefore, inserting the DNA of interest into the TDNA ensures that when the TI plasmid is put back into the *A. tumefaciens* the DNA of interest is inserted into the plant's DNA. The altered cells then reproduce and can be used to generate plants with that specific genetic sequence only. The plants, when modified correctly, will express the new desired trait and contain the genetic modification in every cell within it.

Utility Patents

As evidenced by the discussion given above, the process of creating a genetically engineered plant is extensive and time consuming, and requires a large amount of specialized knowledge. The insertion of DNA from one organism into another is the key point in which the host becomes an "invention." Under patent law, the term "invention" can be applied in a more general sense to a process, a machine, an improvement of an idea or, as in the case of genetically modified organisms, as a composition of matter.[xi] As a new composition of matter, genetically altered organisms qualify for utility patents, which give even greater protection than those granted under the Plant Protection act of 1930 or under the Plant Variety Protection Act of 1970. Under utility patents, it is not only the variety itself that is patentable, but genetic sequences that have been inserted and the method used to engineer the plant.[xii] This is a vast expansion of what is protectable under plant patents which only include the plants at point of sale.

Arguments that patents are necessary to inspire investment in innovation abound. With the introduction of the technology of genetic engineering to plant breeding, patent protection has been expanded to include plants, the seeds those plants produce, the genetic sequences that have been inserted into those plants and the techniques used to create them. The broadening of patent law more generally to include living organisms, "anything under the sun created by man[xiii]," and now genes and genetic sequences is a result of this logic. While the promise of a profit encourages many companies to invest in developing these technologies, it is unclear whether this level of protection actually induces more innovation than would occur otherwise. Patents are granted with the assumption of a social contract: the temporary cost to society of exclusion from this information is assumed to be smaller than the net benefit to society of the patented information. This social contract is not being observed. It is because the expanded protection allows for the appropriation of knowledge from a scientific commons, because it stifles scientific innovation, and because it permanently alters the landscape of global food production that it must be critically reevaluated.

Appropriation of knowledge from a scientific commons

A disturbing trend has emerged within the scientific community as a result of the broadening of patent protection. The knowledge that is created within the scientific community, both within the private and public sphere, is being patented in greater and greater amounts. This represents an appropriation of scientific knowledge from common use as patents on current scientific theories, techniques, and equipment take them out of the public's reach. In addition to the legal barriers to knowledge that have been erected, there has been an ideological shift within the scientific community away from the open distribution and analysis of knowledge. With the introduction of patents into the scientific arena, knowledge has become a commodity and as such is highly guarded. This not only constitutes a privatization of the commons but goes against the key codes of scientific inquiry which emphasize the pursuit of knowledge for the common good in an open and accountable manner. The most pertinent example of this legal shift and its effect on ideology of researchers is the Bayh- Dole Act of 1980, which stipulated that all publicly funded entities patent discoveries that arose from their research. Under this act, if a university did not patent an idea or research that the funding agency considered to be patentable, the funding agency was allowed to take out the patent itself. This created a situation in which the law required that knowledge not patented by one entity be patented by another. Mandated patenting occurred as a result of the fear that publicly funded research was not effectively transformed into end use inventions. In order to stimulate the further development and use of base knowledge, Congress decided that such an act was needed. [xiv] This act was deemed necessary as a direct result of the ideological stance of scientists and researchers more generally at that point in time. Scientists generally did not patent their knowledge and new technologies out of recognition that it belonged to the public realm of science. This is is reflected in the fact that in 1979 just 264 patents were granted to universities while in 1997 2,436 were granted. [xv]

Combined with the expansion of what is deemed to be patentable, including the 1980 ruling that patents on living organisms were valid, a large amount of publicly funded information has come to be privately owned. Many new biotechnologies developed following the Diamond v. Chakrabarty ruling have been both patentable and, when publicly funded, required to be patented by the federal government. Not only are genes and genetically modified organisms patentable, but they are now patented in both private and public realms. The increasingly private nature of information can be demonstrated by the fact that the patents received by universities increased to 2,436 in 1997,[xvi] a number that is surely much higher today.

Federally funded research occurs with tax dollars, money that the public designates for projects important for the common good. When that same information is privatized, the public must again pay to use it in the form of licensure. This too, under patent law, is legitimized as serving the greater social good. One must wonder why the public must pay twice for information when that information is thought to serve the greater social good. If the public must pay twice for this information, is the true net social benefit greater than the social cost?

Furthermore, it is unclear as to why ownability has become pervasive within the university system. In the field of academia, scientific research is supposed to be done without bias and with the intent to understand. What happens to university research when it becomes subject to market imperatives? Rather than investing public research into much needed problems, with little economic returns (which is of great resource given that the research done by large multinational corporations is driven simply by the need for profit), the university has come to function like a corporation, researching with the intent to patent. That the federal government would mandate such a system is an implicit support of the patenting of information for the granting of intellectual property rights. This amounts to a full fledged attack on the scientific commons.

Appropriating knowledge from a publicly funded source was intended to help make scientific discoveries useful and pave the way for the further private development of these ideas. Within this particular model, the university serves as a research center for baseline information which is to then be funneled to industry. Industry is then able to take that information and find a valid use, profiting from its work. While this may serve the benefit of helping universities recover some of the capital investments made to develop these ideas, techniques and tools, it is unclear why such measures are necessary, given that they already have the funding to conduct this research. The public has given money to this cause with the notion that the research agencies involved will help solve some of the problems that society faces. This is a vital service to the public because it ensures that the needs of society are addressed and that some information will be freely available. Freely available information is of interest to all, both those in private and public institutions, because it is necessary for new ideas to be formed and progress to be made. This, afterall, is the underlying logic to patent law.

Stifles Scientific Innovation

When ideas are privatized and knowledge is appropriated from a scientific commons, there is a delicate balance between providing inventors the incentive to take the financial risk of investing in a particular technology and keeping all others from innovating because of the restrictions put in place. Patent law has historically attempted to maintain this balance by keeping the basic scientific knowledge needed to create new inventions publically available. Hence, patent law does not recognize laws of nature, mathematical theorems, and naturally occurring substances to be patentable.[xvii] However, the broadening of patent law to include genes and the techniques of genetic modification has tipped the balance of innovation and now stands to prohibit scientific advancement rather than advancing it.

The technology of genetic modification has evolved from a complex mixture of biology, genetics, and engineering, the basic theories of which are freely available to the public as part of scientific knowledge. The basic "natural laws" from science, for instance those about cell reproduction, are those that form the backbone of knowledge and ideas that are used to create new genetic sequences. In simple terms, the technology of genetic modification would not exist today if the scientific information that was used to create this process had been patented. The new ideas of today, which have been created from unpatentable baseline theories, are the baseline theories of tomorrow. It is because sharing scientific knowledge is necessary in order to discover new truths and invent new technologies that it is counterproductive to withhold new information from public use for 20 years after its development.

This form of government granted monopoly shapes the manner in which scientific advancement occurs. By assuming that profit is the main incentive for scientific advancement and granting those rights exclusively, the laws are set up only to reward inventors for inventions that will do well in the marketplace. As such, inventors create things with the expressly with the market in mind. While the market is assumed to provide goods from which consumers will get the most value, it is clear that this depends on a number of factors. The market may be skewed by the ability of consumers to pay for a particular invention. Thus, those who will not be able to purchase a particular technology will not be able to find products that meet their needs. In the event that there is a social problem faced by the poor, there is no incentive to solve that problem because there is no profit to be made.

In addition to affecting what new technologies will or will not be developed, this process shapes who can take part in developing the technologies. The corporations and scientists who were first able to manipulate the genetic code were the first to receive utility patents. These actors were those with enough capital to finance these expensive endeavors, and therefore the primary holders of patents within genetically modified organisms are large corporations. It is no surprise that corporations, whose main goal is to produce a profit for stakeholders, hold many patents which grant them exclusive rights to make a profit on their developments. This structure of corporations investing in a technology with the market in mind shapes the way that research and development proceeds. Brian D. Wright, Professor of Agricultural and Resource Economics at the University of California at Berkeley confirms this when he writes:

> "Earlier attempts to commercialize genetically engineered potatoes, tomatoes, tobacco, and wheat have been abandoned in the face of low profitability and consumer acceptance issues. Leading agricultural biotechnology firms have increasingly focused on a small set of crops with large markets of high aggregate value, including soybeans, corn, cotton, and canola."[xviii]

Clearly, the profitability of an invention is a large factor in determining whether or not it is made and often comes before solving an agricultural problem. Thus, those with little purchasing power will not have plants developed to suit their needs because they do not represent a lucrative market share. Crops local in nature will be overlooked, as they are not generally seen as cash crops with export value. The oversight of agricultural needs occurs anywhere from California to Colombia.

Those who may want to develop alternative improved plant varieties using the technology that has just been developed cannot because the basic information needed to make a genetically modified organism has been patented. Researchers cannot use the appropriate tools and techniques without first purchasing a license- which, depending upon the purpose can range from fairly straightforward to particularly difficult depending on the use.[xix] The oft cited Golden Rice variety illustrates how patented technologies threaten to halt scientific innovation. Scientists made a variety of rice that would help people around the world with vitamin A deficiencies (VADs), which are estimated to affect 124 million children in the 26 countries globally in which these diseases are pervasive.[xx] The scientists developing this modified rice took genes from a particular type of dandelion called *Narcissus pseudonarcissus* and genes from a bacterium and added them to the rice genetic code. This allowed the rice to express the protein beta-carotene, which the human liver is able to transform into vitamin A, leading to a 20 fold increase in the amount of beta carotene found in this rice. The development of this enhanced variety of rice proved lengthy and complicated; in order to make it, scientists used no less than 70 patented technologies.[xxi] While this particular variety of Golden Rice continued to be developed despite the difficulties involved, it is easy to see that without extensive financial and legal resources, many scientists are unable to continue their research.

It is even more difficult to obtain the rights to sell a marketable variety developed using patented technologies. Corporations that give licensing for this purpose often want royalties from sale of the new crops and technologies made in the process. This can be a difficult negotiating process for both parties but particularly for scientists without extensive resources. For scientists who would like to improve local crops unlikely to be developed by large multinational corporations, the process of obtaining rights to sell them is extremely difficult. Few have extensive legal background or the resources to purchase private council who can effectively negotiate with large multinational corporations.[xxii] Filling the gaps in what corporations develop is therefore almost impossible because the scientific developments are hard to make. The social costs to users in this example are quite high: those who wish to plant better local crops cannot and their needs go unmet. This brings the following question to the fore: how high can social costs become before they supersede the value in keeping an invention private property? This threshold must be considered as the current trends in patent law are moving towards upholding private property rights above the rights of scientists, users of the technology, and the greater common good of human rights to adequate food and shelter.

Permanently alters the landscape of food production

The private property rights of those who hold utility patents on genetically modified organisms are also beginning to supersede the rights of farmers. Patent holders have an exceptional amount of control over the use of their patented plants because the utility patents include the genetic sequences within the plants. Whereas under the Plant Patent Act of 1930 and the Plant Variety Protection Act of 1970, protection stopped at the point of sale, now patent holders can keep users of the plants from breeding their plants or replenishing their seed stock under threat of a lawsuit. Previously, one was unable to identify the exact origin of a plant produced using traditional plant breeding methods, but with the development of genetic manipulation came the development of genetic testing. The unique genetic blueprint of genetically altered plants makes it easy to prove that one has infringed on a patent.

The dangerous part of having a sexually reproducing plant that has such legal protection is that it will reproduce with other, non modified plants, the genes of which will be transferred and grow in new areas. In such cases, it is impossible for farmers to visibly identify those plants with altered genetic information. As a result, many farmers come to grow altered plants without their knowledge, without actively growing them, and without capitalizing on their "improvement." The farmer's intent does not matter. Patent law, as a stringent form of intellectual property rights, protects the idea itself, so the intent of those who infringe on patents does not matter. If this were the case, those who unknowingly made the same invention would not be held accountable for patent infringement and thus the patent would have no substance.[xxiii] Thus, farmers through no fault of their own can infringe on patent rights and are held financially responsible.

While it may seem counterproductive for multinational corporations to sue individual farmers, it happens regularly; there is economic incentive in establishing precedent early to keep other farmers from using the plants without a license.[xxiv] Companies feel that using these farmers as examples will keep others from infringing on the patent. The fear of a lawsuit, combined with the likelihood of encountering gene flow from genetically modified crops to unaltered crops, is used to motivate the purchase of these technology systems, even if just to avoid the legal liability. Because of the legal intricacy of the matter, this system is nearly impossible to navigate without extensive financial and legal resources. The threat of a lawsuit forms an incentive to switch to this new technology system because the financial resources needed to defend oneself in just one lawsuit are enough to wipe out farmers.

The legal liability created by utility patents has a large effect on the way that farmers continue their livelihood; the traditions of seed saving and organic farming are at risk. Farmers who wish to participate in the tradition of seed saving can no longer do so because of the risk of genetic contamination and the law suits that often arise. Seed saving is a tradition of selective breeding in which farmers save seeds from plants with desired traits from one year to the next. This contributes to the cultivation of plant varieties well suited to a particular geographic location. However, with the introduction of genetically modified crops, saving seeds from one year to the next may result in inadvertent saving of genetically modified seeds. Not only do farmers find their seed stocks forever altered, but they also may find themselves legally liable for damages.

Organic farmers are at risk as well because of the transfer of genes among sexually reproducing crop plants. Some genetic modifications allow plants to produce proteins which are not organic. When organic crops come to contain these sequences and produce these proteins, they will no longer be considered organic, which can cause the ruin of a profitable business. In these cases, farmers are unable to sue patent holders for the damage of their private property. The only legal avenues that are provided to farmers who have had their property damaged by this form of "pollution" are under the tort claims of trespass or nuisance as well as the more general claim of negligence.[xxv] Within these bounds, it is the neighboring farmer, rather than the corporation, who is at fault for the contamination. In such cases, farmers must be able to prove the source of the seed without a doubt in order to collect damages. This situation pits neighboring farmers against one another in their attempt to avoid both legal liabilities to the patent holder as well as to surrounding farmers.

Conclusion

When examining the effectiveness of using genetically modified food to "solve" the problem of world hunger we must consider how much access those who would most benefit from these developments would actually have to the technology. It has been demonstrated within this chapter that the broadening of patent protection has led to the privatization of many more food sources and the techniques used to make those crops. Corporations claim that their products will feed the world but still want to make a profit. They sell these products to farmers and ensure that they must purchase rights to the technology each year. While this makes sense from a business perspective, it does not solve the problem that it claims to solve. This form of control is even more pervasive because the very tools needed to develop alternatives to this system are owned. While it is true that the objects, ideas, and techniques in question become *unownable* and hence available to all after 20 years, this length of time is unacceptable when the lives of people in the present are at stake. We must consider the boundaries of private property rights and how they interact with the rights of other members of society. Should private property rights supersede the public's right to eat?

An alternative exists to this system of patent protection or open to appropriation from the commons. Many scholars have identified the success of software development under the general public license as a model for the sharing and building of scientific information, specifically that surrounding genetics. Software developers have made a useful software, Linux, that competes with computer giant Microsoft's word operating system. This system is the result of the collaboration of many programmers around the world who have put effort into the development of this system free of charge. They too faced the problem of having their inventions patented if they themselves did not "own" it already. The actions they took were to copyright the work and then issue a general public license to users and programmers alike. Since the software is copyright protected, no one can take it out of the commons and make it private property. However, using a general public licensing agreement, users are able to access, change and distribute the code as long as they document changes they have made to it, pass on all free information that they themselves have received, and give subsequent users information about their rights under the copyright laws.[xxvi] This has allowed many different programmers to work on the same project and collaborate to make it better. The users feel free to distribute their work because they know that no one will unfairly profit from their work. A true information commons has emerged that inspires people to create, contribute, and collectively work towards a better end product. It offers an alternative to privately developed and owned software and gives the public another option.

This model can serve as a framework for establishing a new means of protecting publicly funded research rather than patenting it. While the capital investment required for genetic sequencing and the manipulation of DNA is prohibitive of individual contributions to this knowledge pool, the idea of pooling information would remain the same for institutions hoping to make contributions to this field of research. When genetic sequences are mapped, or new techniques for genetic manipulation conceived, they can be patented and then a general public license granted for further study. Rather than keeping people from using and refining these new processes, this system encourages it- and encourages the solving of scientific problems for their own sake. While this system of information sharing would not work in the case of corporations, it would be highly applicable for research institutions, especially those that are publicly funded. Not only would the research be used to develop end use products, but these products would be selected by the users themselves. True innovation occurs when knowledge can be used to create new ideas and inventions. The more people who have access to this information, the more likely it is that it will be used in the pursuit of making useful and necessary goods for the benefit for society. In this respect, the general public license more fully realizes the potential of patents.

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[i] *Encyclopedia Britannica*. "Selective breeding." Online ed.

[ii] Henry Mitchell Jr. *The Intellectual Commons* (Oxford: Lexington Books, 2005), 28.
[iii] United States Senate, *Plant Patents,* April 2, 1930 (Washington D.C.: 1930). 2.
[iv] Ibid p. 3.
[v] Ibid p. 3. A sport is defined in the Senate Report given on this act as the portion of a plant that may suddenly assume an appearance or character distinct from that which normally characterizes the variety of species. Sports are plants derived from this variation and not from seeds.
[vi] How are these different?
[vii] United States Senate , *Plant Variety Protection Act,* August 21, 1970 (Washington D.C., 1970), p 2.
[viii] Transgenic Crops: An Introduction and Resource Guide. "Important landmarks in U.S. patent law." http://cls.casa.colostate.edu/TransgenicCrops/patent.html

[ix] Diamond V. Chakrabarty, 447 U.S. 303, 309 (1980) quoting Sen. Rep. No. 1979 (1952).
[x] Griffiths, Anthony J.F., Gelbart, William M., Lewontin, Richard C., Miller, Jeffrey H. Modern Genetic Analysis: Integrating Genes and Genomes. 2nd ed. New York: W.H. Freeman and Company p. 36.
[xi] Mitchell, *The Intellectual Commons*, 28.
[xii] Brian D. Wright. "Plant Genetic Engineering and Intellectual Property Protection" *Agricultural Biotechnology in California Series* 8186, (2006) p. 2.
[xiii] Diamond V. Chakrabarty, 447 U.S. 303, 309 (1980) quoting Sen. Rep. No. 1979 (1952).
[xiv] Rai, Arti and Rebecca S. Eisenberg. "The Public Domain: Bayh-Dole Reform and the Progress of Biomedicine," *Law and Contemporary Problems* 66, prob. 289 (2003).
[xv] Ibid. 2
[xvi] Ibid.
[xvii] Mitchell, *The Intellectual Commons*, 28.
[xviii]Wright, "Plant Genetic Engineering and Intellectual Property Protection" ,3.
[xix] Colombia article
[xx] Stephen Nottingham. *Genescapes: The Ecology of Genetic Engineering.*(London: Zed Books, 2002),165.
[xxi] Keith Aoki. *Seed Wars.* Durham: Carolina Academic Press, 2008.
[xxii] Study from colombia
[xxiii] Mitchell, *The Intellectual Commons, 57.*
[xxiv] Ibid p. 5
[xxv] Moeller, David, R. "GMO Liability Threats for Farmers," *Farmers' Legal Action Group, Inc.* November 2008, 3.
[xxvi] *GNU Operating System. "*General Public License." http://www.gnu.org/licenses/gpl.html.

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