Repairing Incentives to Invest in Plant Breeding

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SUMMARY

In recent years, several factors have been eroding the value of the incentives provided by the International Convention for the Protection of New Varieties of Plants (UPOV) for investment in developing varietal improvements. Of these factors, those arising from biotechnology have been especially important. Some leaders in the industry have seen a remedy in transferring the protection which patents have been providing for the results of genetic research in recent years, to the activity of plant breeding. Unfortunately, new plant varieties are achieved through incremental changes, and patents are intrinsically unsuited to this. Current proposals for their reform, however, include three which might be especially appropriate for plant variety protection. The common element in these is removal of the monopoly component in the protection means. This article discusses how far this could be done without harming the incentives needed for investment in the research and development needed for new plant varieties.

INTRODUCTION

The most prevalent type of intellectual property for plant breeding is provided by the International Convention for the Protection of New Varieties of Plants (UPOV). This was established in 1961, and now has 54 Member States. The United States had introduced Plant Patent protection, but only for asexually propagated varieties, in 1930, but this has not been copied elsewhere.

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A 2006 Report from UPOV has set out its achievements in some detail.[1] This records that for the 20 countries which joined it up to 1992 (ten from the European Union and ten others):

> ". . . farmers, growers and breeders have had access to the best varieties produced by breeders throughout UPOV member territories and have been shown to have been taking full and increasing advantage of that opportunity."

Countries which joined between 1993 and 2000 (ten from Latin America, eight "in transition to a market economy" and seven "others,") were also studied for the report. It was found that in these, membership of UPOV has also led to:

> ". . . a substantial demand for variety protection, as well as important technical assistance and . . . opportunities for co-operation, which enables PVP (plant variety protection) to be extended to the widest range of plant genera and species in an efficient way."

Because of course the report is discussing UPOV's achievements, it makes no mention of the use of trade secrets by growers, which can be credited with the development of hybrid maize, nor of how patents have contributed to transgenic traits in the improvement of soybean. Nor does it advert to current concerns amongst practitioners about emerging trends in relation to protection of plant breeding and access to plant generic resources.

These were aired at the International Seed Federation's 2004 Seminar on Protection of Intellectual Property and Access to Plant Genetic Resources.[2] Breeders face two new problems in particular, the first of which is the impact on them of new techniques, especially those of biotechnology. Their second difficulty arises from understandable but poorly informed attempts by poorer countries to gain more value from the wild genetic resources which they are capable of supplying. These factors, together with the inherent biological challenges associated with identifying useful exotic germplasm and incorporating it into improved varieties, have caused breeders to look elsewhere for many of their sources of germplasm to advance agronomic performance. For example, they have used the FAO International Treaty, or they have been content to source less exotic germplasm.

NEW BREEDING TECHNIQUES

It is characteristic of innovation in plant breeding to be predominantly incremental, proceeding by progressive enhancement of a particular variety through the introduction of desired traits from other sources. This requires investment at high risk, because even

[1] UPOV Report on the impact of plant variety protection No.353(E), January 2006. Executive summary available at: *http://www.upov.int/en/about/pdf/353_Executive_Summary.pdf* [Accessed June 25, 2007].

[2] International Seed Federation 2004. May 28 Seminar on Protection of Intellectual Property and Access to Plant Genetic Resources. Papers available in *Bioscience Law Review*, Vol.7, No.1, 2003–2004.

the process of trying such introductions may take several years, and in the end it may not result in an improvement that is commercially successful.

Plant breeding consequently can only be carried on by public authorities, or by private entities which can rely on intellectual property protection. Without this, a breeder who has taken no part in a successful private sector breeding programme could freely copy and make money out of the result, thus depriving the originator of reward for his risky investment of both money and creative effort.

The incremental nature of innovation in plant breeding is reflected in UPOV's "breeders' exemption," which allows protected varieties to be used as breeding material without the need for permission from the holder of the rights. In the early years of the UPOV Convention, the incentives it provided were reasonably well matched to private breeders' needs, especially for breeders of self-pollinated crops where previously there had been only contractual agreements as a legal basis for protection. This indeed led to the development of many new varieties, and an aspect of this matching was the rough correspondence of the term of protection with the length of time it took competitors to use the breeders' exemption to develop competitive products and put them on the market.

CHANGES TO UPOV

However, this correspondence was progressively undermined by the development of genetic engineering and by advances in technologies which facilitated access to germplasm and shortened the length of breeding cycles. The 1980 US Supreme Court decision in *Diamond v Chakrabarty* allowed microorganisms to be patented,[3] and in 1985 in *Ex p. Hibberd* it was ruled that utility patents could be granted for plants. The first patent claiming a new plant variety per se (for an inbred corn line) was issued the following year. However, the status of patents for the results of genetic engineering in plant breeding was not fully certain until the Supreme Court's positive decision in the *J. E. M. Ag. Supply v Pioneer Hi-bred* case in 2002.[4] This was to the effect that nothing in any other legislation, such as the Plant Variety Protection Act, precluded the grant of utility patent protection for plants. Congress had had ample opportunity to change this situation if it wished, the court observed, but had opted not to do so.

It consequently became accepted that protection needed to be strengthened if breeders were to have enough incentive to invest heavily in their risky programmes, with the result that UPOV was modified in two important ways in 1991. First, the term of protection was increased from 15 to 20 years, and secondly, the concept of "genetic distance" or "dependency" was introduced, to enable breeders to benefit from improvements to their varieties made by others. If the germplasm of a new inbred is:

> ". . . predominantly derived from the initial variety, while retaining the expression of the essential characteristics that result from the genotype or combination of genotypes of the initial variety",

[3] *Diamond v Chakrabatry*, 447 U.S. 303, 1980.
[4] *J. E. M. Ag. Supply v Pioneer Hi-bred*, Supreme Court of the United States, No.99–1996, April 15, 2002.

it is "dependent" on the initial variety, and it cannot be commercialised without the permission of the owner of the relevant rights.[5] As one illustration of the "genetic distance" which defines dependency, the International Seed Federation (ISF) guidelines for maize using Simple Sequence Repeat genetic markers are that 82 to 89 per cent similarity indicates possible dependence, and that 90 per cent or more definitely does. Similar guidelines are being developed for other crop species under the auspices of national and regional seed associations and the ISF.

However, many Member States did not adopt the new provisions of the 1991 Act, and Troyer and Rocheford hold that the changes "are unwieldy and inhibit progress".[6] Their empirical research showed that agronomic trials were better identifiers of whether varieties were distinct (initial varieties, or IVs) or dependent (essentially derived varieties, or EDVs) than molecular methods alone. Lesser and Mutschler go even further, claiming that "the UPOV approach to improvement is ultimately unworkable"[7] because it tries to cover both discrete and complex enhancements through a single system.[8] According to them, "there are virtually no known examples of the application of initial variety status",[9] and they argue that such incentives as the present system offers to breeders actually lead to socially inefficient outcomes. This is because they push a breeder towards using his or her own or unprotected varieties in his programme rather than the best varieties available. They encourage

> ". . . the selection of genetic material of no practical value other than reduction of relatedness. Such cosmetic breeding rewards the company for accomplishing a breeding goal that does not contribute anything of practical agronomic value, so is socially inefficient. It also reduces royalties to the initial innovating breeder, thereby reducing the potential benefits to society that intellectual property is intended to generate."[10]

Reports cited by Troyer and Rocheford indicate that because of the incoherence of UPOV's protection arrangements, "[d]etermining inbred ownership has become very complicated, very time-consuming and very expensive." Annual litigation expenses in the US hybrid seed-corn industry alone, they claim, now exceed $100 million.[11] It may be that this figure relates to disputes concerning genetic engineering rather than to actual ownership of specific varieties. If this is the case, it would be an aspect of the escalation of patent litigation costs generally, which has been leading them to exceed research and development costs in the United States by an increasing amount each year.[12]

The increased term of protection under UPOV 1991 has also not worked as well as had been hoped, because a suite of new technologies, including high-throughput

[5] UPOV 1991 Act Art.14.5(5)(b).
[6] A.F. Troyer and T.R. Rocheford (2002) 42 *Crop Science* at pp.3–11.
[7] W. Lesser and M. Mutschler, "Balancing investment incentives and social benefits when protecting plant varieties: Implementing initial variety systems" (2004) 44 *Crop Science* at p.1114.
[8] Lesser and Mutschler, p.1118.
[9] Lesser and Mutschler, p.1119.
[10] Lesser and Mutschler, p.1116.
[11] Troyer and Rocheford, cited above fn.6, p.9.
[12] J. Barton, "Reforming the Patent System" (2000) *Science* 287 at p.1933.

molecular marker capabilities, genomics and off-season nurseries, has enabled breeding procedures to be greatly accelerated. This has focused attention on the *effectiveness* of protection rather than on how long it lasts. The result is that it is now being argued that UPOV's arrangements no longer provide the incentives needed to underwrite an adequate level of private sector investment in the risky and long-term components of germplasm development. Worse, these incentives are being eroded precisely when the public sector is also under growing resource constraints.

UPOV STATISTICS

The effect of this erosion of incentives is not adequately revealed in the statistics of registrations under UPOV. The annual total of such registrations increased by 30 per cent from 6,493 in 1999 to 8,473 in 2005.[13] There has been a significant decline in registrations in Germany and the Netherlands, both important plant-breeding countries, but these are explained by their breeders' growing preference for registering via the European Community route. However, what is far more important than the raw numbers is the *quality* of the new varieties that are registered. Troyer and Rocheford point out that:

> "The quality (positive effect) of introgressed DNA improving useful agronomic traits is more important than quantity of DNA similar to the initial variety parent."[14]

If many of these so-called new varieties are the result of what Lesser and Mutschler call "cosmetic" pre-breeding, as seems likely, then the evolution of the industry is in the direction of a shrinking rather than a widening genetic pool.

PRESSURE FOR PROTECTION BY PATENTS

The emerging shortcomings in their own specialised protection system have led some (American) breeders to call for new arrangements for plant variety protection which would parallel those now granted to biotechnology discoveries by patents. The largest and most advanced firms, such as Pioneer Hi-Bred International and Monsanto, want patents to be part of a suite of protection methods. These would include a revised breeders' exemption in plant variety protection so as to facilitate access to germplasm for research purposes.

Pioneer was a party in the legal case which finally settled that utility (ordinary) patents in the United States could be used to protect genetic engineering in plant varieties, and a former head of this firm has argued that:

[13] UPOV, Plant Variety Protection Statistics 2006, Geneva.
[14] Troyer and Rocheford, p.6.

> "DNA sequencing and genomics techniques enable plant breeders to find new, useful alleles within germplasm faster and more effectively. Improved genetic materials raise the probabilities of providing better performing commercial seed products with a broader base of genetic diversity . . . Globalization and pressure on public budgets in many industrialized countries have shifted the balance of crop improvement from public institutions to private organizations . . . There will be fewer public sector plant breeders and relevant plant breeding programs. If intellectual property protection is not improved, farmers will have fewer differentiated seed products to choose from . . . Protection must keep pace with technology change . . . Without stronger intellectual property protection, investments in technology and germplasm will not be sustained."[15]

Such hopes on the part of large-scale plant breeders that rescue might come through the patent system are understandable, but unfortunately for them, patents are intrinsically unsuited to the creative early stage of the plant breeding process. The patent system operates on a basis of *explicit* information, whereas breeders need is for an incentive to access and use a diversity of germplasm that is only partly understood. The first and most risky stage of plant breeding is concerned with developing improved adapted germplasm using less adapted and more exotic sources that are not well characterised. The disclosure requirements of the patent system require a breeder to try to provide precise descriptions of specific genes and gene/trait associations before it is yet possible for him to characterise the breadth of genetic complexity with which he is dealing.

EXEMPTIONS FOR RESEARCH

Until the US 1952 Patents Act, inventions required evidence of a "flash of genius' to be patentable, but this is not to be found in the incremental procedures by which new plant varieties emerge. Indeed, it was because of difficulties in defining anything comparable to "invention" in plant varieties that the United States passed its Plant Patent Act in 1930, and that UPOV was subsequently brought into being on European initiatives. The patent system protects invention or discovery *directly*, but it protects innovation only *indirectly*, through the latter's link with the invention. In contrast, UPOV protects innovation directly, because its subject matter is nothing earlier than the developed variety, distinguishable, novel, homogeneous and stable. There is an irreconcilable difference between the two approaches to protection.

The smaller seed firms which note the larger ones arguing for patent protection, and fear this, may consider that it could be acceptable if its "research exemption" was modified so as to have the same scope as what UPOV now offers them in "breeders' exemption." Unfortunately, however, the patent research exemption has been given

[15] R.L. McConnell, "Developing genetic resources for the future—the long look", International Seed Federation Seminar on Protection of Intellectual Property and Access to Plant Genetic Resources, (2004) 7 *Bioscience Law Review* 1 at pp.2003–2004.

a narrow interpretation in the 2002 *Madey v Duke University*[16] decision in the United States, and even though the Supreme Court has relaxed this somewhat in *Merck KGAA v Integra Lifesciences*,[17] it still does not compare with the unlimited freedom to experiment with protected varieties which UPOV offers breeders.

What are the chances that patent law might be revised so as to make a special exception in this respect for plant varieties? This would be such a fundamental break with patent tradition that it is highly unlikely even to be considered. That tradition, in fact, tends strongly in the direction of a unitary system, so that as new forms of information needing protection such as computer software and DNA, came into existence, they were shoehorned into the patent system instead of being given their own *sui generis* arrangements. Plant protection by patents has little hope of getting any different treatment to that given to the other types of information with which the system deals.

Use of patents in their present form by plant breeders could therefore have the perverse effect of narrowing the germplasm base, by tending to encourage research for relatively minor genetic changes in varieties that are already well understood and well adapted. Research investment invariably tends to focus on what can be protected. Lesser and Mutschler concluded that overall, the application of patent protection to the essential derivation of plant varieties "is perhaps too complex to be warranted".[18] Some breeders consequently advocate revision of the plant variety protection regime so as to incorporate certain aspects of the patent system instead.

BIODIVERSITY, ACCESS AND BENEFIT-SHARING

The tendency towards "cosmetic pre-breeding" associated with current and proposed protection of new plant varieties would be less worrying if it was being balanced by increasing inflow of new plant genetic resources from the countries which have these in plenty.

Traditionally, such access was free, but even before the United States began to issue utility (ordinary) patents for plants, there had been some widely publicised cases where large amounts of money were made by firms in the developed world on the basis of materials which they had obtained for little or nothing in poor countries. In the hope of preventing this, the Convention on Biological Diversity (CBD) was brought into being in 1992, to further natural resource protection and benefit-sharing. A key feature of this is that natural resources could only be used with "prior informed consent."

Unfortunately, this requirement backfired on the countries which promoted the CBD, because of the practical difficulties in operating it. For example, the idea of prior informed consent became hopelessly entangled with the impossible task of Certification

[16] *Madey v Duke University*, Court of Appeal for the Federal Circuit, USPQ2d 1737 (Fed. Cir. 2002). No.02–1455.

[17] Merck KGAA v Integra Lifesciences I, Ltd, et al. No.03–1237, Supreme Court of the United States, decided June 13, 2005.

[18] Lesser and Mutschler, cited above fn.7, p.1119.

of every wild resource in poor countries. The main potential users of such resources at present are the international pharmaceutical firms, but these have become increasingly reluctant to undertake the frustrating task of trying to get the prior consent prescribed by the CBD. Their attitudes were hardened because many of their negative experiences occurred at a time when combinatorial chemistry and methods of synthesis were rapidly improving. Because of these, drug firms can now produce new molecules without having to tap in to natural resources, with all their associated problems of compliance with the CBD. Consequently, almost all of the large firms have now ceased to collect samples of natural products and to isolate extracts from them.[19]

This has serious implications, because it represents a further narrowing of the focus of research and development instead of broadening it towards the genetic diversity which both the drugs and the seed products of the future will need. The 2001 International Treaty on Plant Genetic Resources for Food and Agriculture, which entered into force in 2004, takes a quite different approach for benefit-sharing to the CBD, and does not require "informed consent". Instead, access to genetic resources will be through a Material Transfer Agreement, the wording of which has involved protracted negotiation. This is intended to include a benefit-sharing mechanism whereby users of germplasm will pay to support conservation and utilisation programmes, primarily in developing countries. Some of the more active breeders advocate the payment of royalties irrespective of the type of protection, as long as inbred parent lines of hybrids are not made available without restriction for further breeding.

ALTERNATIVE TYPES OF PROTECTION

If this Treaty is to have more positive effects than the CBD, it will be necessary for developing countries to come to terms with intellectual property. By joining the World Trade Organisation (WTO), which was established in 1995, they have in any event committed themselves to do this. The Trade Related Intellectual Property Rights (TRIPs) Annex to the WTO agreement imposed an obligation on all Member States to establish Western-style intellectual property arrangements if they did not already have these. In relation to provision for plant variety protection, its Art.27(3)(b) requires that this should be "either by patents or by an effective *sui generis* system or by any combination thereof". This flexibility may offer an opportunity to poorer countries to combine arrangements for protection with those for conserving their biodiversity.

However, if patents are problematical, and UPOV and the CBD are not delivering enough protection, as well as fair access to, and benefit-sharing for the resources of poor countries, are there better alternatives? Several proposals seem to be worth looking at, all of which have in common that the protection they offer does not contain the monopoly component which is fundamental to the patent system. As noted earlier, the incremental nature of plant varietal development is incompatible with the monopoly

[19] S.K. Finston, "Relevance of genetic resources to the pharmaceutical Industry", International Expert Workshop on Access to Genetic Resources and Benefit-sharing, Cuernavaca, Mexico, October 24–27, 2004.

(albeit time-limited) that is intrinsic to the concept of a patent, and this is dealt with in the UPOV system by the breeders' exemption. Parental inbred lines that can be maintained as trade secrets of course remain inaccessible to competitors.

The patent system has its own problems, and has been the subject of increasingly negative criticism of late. However, as a means of encouraging invention, it has the outstanding advantage of having the potential to stimulate the widest possible range of human imaginations to search for and find new things of potential economic value. It then provides the incentive for the human creative efforts needed to turn these into concrete reality —as Abraham Lincoln said of it, "it adds the fuel of interest to the fire of genius". The public records of the world's patent offices testify to how vast this range of inventive effort is. By far the great majority of patented inventions come to nothing, but equally their cost falls only on those who hoped to gain from them, and society as a whole is not involved in loss. In the most usual alternative method of encouraging invention, public subsidy of research and development, the failures are funded by taxpayers.

PRIZES

Another way of using public money to encourage invention and innovation is to offer prizes for success. This has certainly had two well-known achievements, the chronometer and preservation of food by heat treatment.[20] However, prizes can only be offered if the authority granting them can specify the required achievement in advance with high precision, as could be done in both these cases (in the first for the needs of the British navy and in the second for those of the French army). Subsidy can be used without the same degree of precision, for example in the Small Business Innovation Programs of the United States, about $2 billion a year is awarded competitively to firms which respond with their own proposals to "solicitations" covering the broad activities of 10 Federal Agencies. However, only patents can provide incentives to those whose imaginations go beyond anything that the public authorities can envisage and take seriously as "information".

A variant of the prize system is for the state to deliver rewards *ex post*, as was used in the Royal Commissions on Awards to Inventors which sat after both World Wars. Masters has proposed this approach as means of improving tropical agriculture.[21] A major difficulty with this approach is the vast scale of the amounts of money required to be distributed at the discretion of the expert assessors. In the case of the Royal Commissions, what was at stake was rewards to individuals, not to firms for major investment programmes. For example, Sir Frank Whittle was awarded £100,000 for the jet engine, which, although large, was trivial in relation to the investment made by firms (but ultimately by the government) to develop it. Imagining the scale of this investment

[20] See B.D. Wright, "The Economics of Invention Incentives: Patents, Prizes and Research Contracts" (1983) 73 *American Economic Review* 4 at pp.691–705.

[21] W.A. Masters, "Research prizes: a mechanism to reward agricultural innovation in low-income countries" (2003) 6 *AgBioForum* 1 & 2 at pp.71–74.

suggests the impossibility of delegating decisions about awards for innovation, as contrasted with invention, to any group of experts. If the prizes to be offered had to be worth the modern equivalent of the £10,000 for John Harrison's successful chronometer in the mid-eighteenth century, they would hardly be politically acceptable.

Comparable rewards for success due to patent protection are acceptable to the public because it is recognised that they are not discretionary. The scale of such rewards is the result of the increasing dependence of invention and discovery on *investment*. The patent system which is now effectively worldwide was originally established to protect the "creations of the minds" of what we today would call individual inventors, by granting them a monopoly of using the information they had generated, for a limited time. This was the only way of giving protection then, and it still is the best way to protect the inventions of individual inventors and small firms (SMEs). However, these sources now only account for a small fraction of inventive output, most of which is the result of investment in purposive research and development by large firms.

The prospect of patent monopoly is of course attractive to firms, but in terms of directing their investment in research and development (R&D) towards fruitful innovation, it has numerous drawbacks. The standard economists' objection to monopoly, that it results in fewer goods being produced at higher prices, is not one of these, since the intention is specifically to permit the patentee to charge a high price for a period and so obtain a return on an investment which had to be made under risk or even uncertainty.

Much more damaging to society as a whole is the extent to which innovation may actually be slowed down and the focus of research and development narrowed, by patent protection in its present form. The slowing down of innovation occurs because the development of any significant breakthrough takes place through incremental improvements along a technological "trajectory". No firm can exploit more than a single trajectory well, so that to the extent that the patent monopoly is effective, exploitation of the breakthrough by other firms along other trajectories will be delayed.

To avoid this delay, competitive firms will invest in R&D to "invent around" a patent which is frustrating them, using funds which could be expected to produce more and better innovations if they were invested instead in original research. An alternative policy, frequently carried on in parallel with the first, is simply to infringe the patent. This inevitably results in litigation, which is even more wasteful of resources and creative energy. It is an unfortunate reality that in the United States today patent litigation costs are increasing faster than investment in R&D.[22]

For these reasons, it is hardly surprising that several proposals which have been made for reform of the patent system have removal of its monopoly feature as a common element. This of course would have to be done without damaging the incentive to invest in R&D, and it is in the means of achieving this that the proposals differ. Because they correspond to the "breeders' exemption" in the UPOV system, these proposals may help to reconcile plant breeders' claimed need for stronger protection with the freedom of access to information which is essential for every kind of incremental innovation.

[22] J. Barton, "Reforming the Patent System" (2000) 287 *Science* at p.1933.

A "COMPENSATORY LIABILITY REGIME"

The proposal for eliminating monopoly from intellectual property protection which is closest to what UPOV already offers is that of Jerome Reichman's "compensatory liability regime" (CLR). Although he first developed it fully in an article entitled "Of Green tulips and Legal Kudzu", this is not specifically directed towards plant variety protection, although it is certainly included.[23] It has much more general application, and in fact Reichman claims that it is "a third intellectual property paradigm", patents and copyright being the first two.

"Kudzu" is a Japanese vine which was brought to the United States to prevent soil erosion, but which has spread uncontrollably all over the southern states. Reichman uses it as a symbol for the way in which patents and copyright have been stretched far beyond their capacity in attempts to protect new kinds of information:

> ". . . these hybrid intellectual property regimes, and the suffocating weed-like thicket of exclusive rights they breed, threaten to throttle more innovation than they could ever possibly stimulate."[24]

"Stretching" of patents to cover plant variety protection, via the granting of patents for biotechnology, would reflect further emphasis of legal "kudzu", and in fact Reichman writes that his model

> ". . . was partly premised on the need to protect novel plant varieties under international intellectual property law. It was intended to demonstrate the superiority of liability rules over the patent-like hybrid regime that developed countries are seeking to impose on the developing world."

A patent is a property right, in that it forbids the use of the protected information *absolutely*. With a liability regime, in contrast, anyone is free to use the information, subject to paying compensation to the originator.

Reichman advocates a compensatory liability regime as the appropriate norm for the protection of all forms of "subpatentable inventions", that is, improvements which are not able to meet the full criteria of novelty and non-obviousness required by the patent system. Such improvements are:

> ". . . the 'routine' engineers' cumulative and sequential working out of shared or common technical trajectories that increasingly drives the post-modern economy in Silicon Valleys and their equivalents throughout the world."[25]

New plant varieties are achieved by just such sequential procedures, and Reichman uses a hypothetical example of this to explain his CLR. In this, A breeds a green tulip

[23] J.H. Reichman, "Of Green tulips and Legal Kudzu: Repackaging Rights in Subpatentable Invention" (2000) 53 *Vanderbilt Law Review* at pp.1743–1798. Reprinted in R. Dreyfuss, D. Zimmerman and H. First (eds), *Expanding the Boundaries of Intellectual Property* (Oxford: Oxford University Press, 2001), pp.23–54.
[24] Reichman, p.1776.
[25] Reichman, p.1750.

for the first time ever, but finds there is no demand for it. B then uses A's technology to breed a green, white and red tulip, which is commercially successful. Other breeders C now cash in on this success with tulips of other colour combinations.

He then shows how existing intellectual property arrangements prevent these innovatory developments from taking place in ways which both reward risky investment in R&D and promote the good of buyers of tulips. These arrangements do not take sufficient account of:

> ". . . the community's role in the process of developing subpatentable innovations through miniscule additions to the common stock of technical know-how accruing from their combined efforts . . . the system tends to make that shared know-how artificially scarce."[26]

In contrast, if a CLR were in force, Breeder B could freely use the new technology which A had developed, and Breeders C could also freely use both A's and B's technology. However, for a relatively short period of years, these users would have to pay compensation for doing so. This would be in the form of royalties in the range of 3 to 9 per cent, settled by built-in mediation and arbitration arrangements.

The potential value of using the liability approach is its capacity to widen the number of innovators who are exploiting information along different trajectories. However, Reichman's proposal is open to the objection that since arbitrators' decisions can be appealed to the courts, it would become unworkable because of litigation costs. He nevertheless remains optimistic that disputes would be limited to:

> ". . . arguing about a couple of percentage points in royalties, ideally before an arbitrator or mediator, [which] is socially preferable to litigating costly actions for infringement . . ."[27]

Reichman claims that as well as protecting plant breeding, what he proposes could also be relevant to plant genetic resources and traditional knowledge:

> ". . . with small amounts of tinkering, a compensatory liability regime could be adapted to encourage use of traditional knowledge without denying the relevant indigenous communities the right to a fair share of the proceeds."[28]

As:

> ". . . a new and dynamic form of 'paying public domain' . . . [I]t bridges the gap between the prevalent view in developed countries that traditional knowledge belongs

[26] Reichman, p.1773.
[27] J.H. Reichman and T. Lewis, "Using liability rules to stimulate local innovation in developing countries: Application to traditional knowledge" in K. Maskus and J.H. Reichman (eds), *International Public Goods and Transfer of Technology Under a Globalized Intellectual Property Regime* (Cambridge: Cambridge University Press, 2005), pp.260 *et seq.*
[28] Reichman, cited above fn.22, p.1797.

in the public domain and the aspirations of many developing country governments for a strong exclusive property right in traditional knowledge."[29]

Means for collecting and distributing payments would be required by a CLR, and as noted earlier, such means are also envisaged by the 1991 International Treaty on Plant Genetic Resources. Reichman claims that it should be no more difficult to organise them for natural resources or traditional knowledge than it has been for a liability regime under US copyright law, where a single private agency deals at low cost with 200,000 private music licences a year.

Such collecting agencies could be associated with gene banks, which are becoming increasingly necessary because of conflicts between the traditional operation of intellectual property rights on the one hand, and the emerging regimes of natural resource protection and benefit-sharing, exemplified by both the CBD and the 2001 International Treaty, on the other. For example, Feyt pointed out that the freedom of access to genetic variability resulting from purposive breeding under UPOV does not apply to a wild plant.[30] This is controlled (and may be prevented) by the CBD and the Treaty. A situation could even arise where a plant variety to which there is free access for breeding during its period of protection under UPOV, becomes the equivalent of a wild variety, with access to it barred under the CBD, when this period is over.[31]

A FINANCIAL MEASUREMENT OF INTELLECTUAL PROPERTY GRANTS

Reichman's "compensatory liability regime" is intended to apply to "improvements that are not able to meet the full criteria of novelty and non-obviousness required by the patent system." However, genetic engineering now enables the results of an increasing proportion of investment in plant breeding to meet these criteria. Consequently, something more than a CLR is needed for flexibility in their protection. Another proposal designed to remove the drawbacks of monopoly in patents is the introduction of a financial dimension into the *measurement* of the grant.[32]

The argument in this case is that measurement of exclusive rights by time only can never be anything more than a surrogate for money. If all inputs and outputs could be measured accurately, then the logic of a grant of protection would have it last until an investor in R&D had received as profit some socially acceptable multiple of the investment made, which also took account of its subjectively assessed risk.

When the practicalities of applying this are investigated, however, it soon emerges that this ideal arrangement is out of reach. On the other hand, focusing on the investment which had to be made *beforehand* to bring about the reproductive or vegetative material

[29] Reichman and Lewis, cited above fn.26, pp.354 & 362.

[30] H. Feyt, "Intellectual Property Rights on varieties and access to plant genetic resources: towards a coherent and an ethically based approach" (2003) 1 *Plant Genetic Resources* 2–3 at pp.97–102.

[31] Feyt, p.102.

[32] W. Kingston, "Intellectual Property Needs Help from Accounting" (2002) 24 *European Intellectual Property Review* 11 at pp.508–515.

of a new plant variety, is much more promising as a way of fairly calculating the price of a compulsory licence for commercial marketing of an "essentially derived" variety. On this point, it has been expertly observed in relation to investment in R&D generally that

"... proving such costs will not be difficult or burdensome. Patent applicants and patentees collect this information anyway for a variety of reasons, including: (i) tax benefits; (ii) internal cost accounting; (iii) use in project evaluation; and (iv) use in licensing negotiations and the like. Patentees appear to have no trouble showing research expenditures at the damages stage of a patent infringement suit, and ... such information has been introduced in some cases to show the non-obviousness of the invention involved. Simply adding one more reason to collect data on the cost of a research project does not appear to pose a major problem."[33]

The concept of the multiple in the ideal (but impractical) approach could then be applied instead to the amount of this investment to define a proper payment for a licence. Such a payment would reflect the investment *and the risk* which the originator had taken to bring the "initial variety" which a follower wants to use, into being.

This approach would mean that the shortening of the time it now takes a rival breeder to develop a product which can compete in the market with that of an originator would no longer matter. Under UPOV's "breeder's exemption", he or she would be free to use the originator's material whilst making his or her investment in R&D. However, instead of then being blocked from entering the originator's market for a term of years, he could now obtain a licence to compete by paying to the originator a prescribed multiple of the measured investment which the original breeder had made under uncertainty and high risk. The follower would in fact be sharing in that investment *and its risk* retrospectively.

EMPIRICAL RESEARCH

The records of the US Small Business Innovation Research Programs (SBIR) were used to examine how the proposed means of adding money to time in the measurement of exclusive rights might work out in practice. The full history of 23,000 cases was tracked, and indicated that a multiple of 2.2 as the cost of a licence would fairly reflect a follower firm's retrospective sharing of the early, critical part of the first firm's investment *and its risk*. No particular value is attributed to this figure, other than as evidence that working out "multiples" is feasible.

EU EXPERT GROUP

This proposal has been studied by a European Union Expert Group, whose report included the following:

[33] R. Merges, "Uncertainty and the standard of patentability" (1992) 7 *High Technology Law Journal* at p.55.

> "No doubt at the time when intellectual property originated, any measure other than time was out of the question, since accounting techniques were undeveloped. But to persist with such a poor measure as time today is simply to ignore all the achievements of accountancy since, which are now capable of providing the measurement required. Many of the problems of intellectual property rights, especially in new fields such as biotechnology and information processing, are actually caused by having to use time as the very crude measure of a patent, copyright or other grant . . .
>
> We think that if both objectives of this proposal could be achieved, there would be considerable benefits in terms of science and technology policy. We therefore consider that although this is clearly a long-term project, it is worth investigating further."[34]

On the face of it, the change proposed appears to have considerable power to increase the strength of existing incentives to plant breeders to undertake the high risks of investment to produce new varieties, without the drawbacks of traditional patents. It would achieve this because the more potentially important any variety is seen to be by competitors, the more licences will be requested for it, and as each licence would cost the same multiple of the originator's investment, he could find that this, however risky it had been, was very well rewarded. At the same time, the wider public interest would be well served because no firm would be prevented from using any protected germplasm it needs as long as it was ready to share retrospectively in both the investment and the risk which had earlier bought that germplasm into being. This could scarcely fail to bring about more "follow on" investment, leading to still newer and better varieties.

In terms of access and benefit-sharing, the multiple which breeders who use new material from a poor country would receive for a licence would only apply to the investment in R&D which they themselves had actually made. Consequently, there would be no possibility of repetitions of the past "biopiracies" which caused so much ill-will in poorer countries, providing the emotional stimulus for the ill-fated CBD and consequent shrinking of the gene pool for drugs as well as for plant varieties.

As well as this, when the genetic resources or traditional knowledge of such countries are being used, the "multiple" payable for a licence could take this into account. Some proportion of it could then be transmitted to the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture, for distribution according to its mandate.

PATENT BUY-OUTS

The most far-reaching proposal for dealing with perceived harms from patent monopoly (and which could be applied to any form of intellectual property) is that of Michael Kremer.[35] This is that the state should extinguish successful patent monopolies by *buying*

[34] ETAN Report, *Strategic Dimensions of Intellectual Property Rights in the Context of Science & Technology Policy*, Section 3.4, 1999, Brussels, Publications Office of the Commission of the European Communities, EUR 18914.

[35] M. Kremer, "Patent Buy-outs: A Mechanism for Encouraging Innovation" (1988) *Quarterly Journal of Economics* at pp.1137–1167.

them out. Although at first sight this might seem to replace the proved value of patents by the dubious effectiveness of public subsidy as means of encouraging innovation, Kremer claims that his scheme offers the benefits of both approaches instead. His argument is briefly as follows:

Society gains much more from successful patents than the patent owners do. Empirical research has shown that the social return to patented invention is much greater than the private return, because of the way in which information "leaks" through the porosity of even the most skillfully drafted patent claims, and of the time limit on the protection granted.[36] This has led Kremer to argue that the state should buy out successful patents for some small multiple of their value as "leaky" monopolies, and put them into the public domain for all to develop freely. He cites precedents for this in the purchases by the French Government of Daguerre's patent for photography and by a group of American states of Eli Whitney's cotton gin invention, both of which became great successes.

Several advantages can be claimed for such an approach. First, funds used for such buy-outs would almost certainly be better spent than by any other way of putting public money into encouraging innovation. The government would only be paying for successes, and even then, only in proportion to the degree of success. Secondly, buy-outs would increase incentives for original research from the perceived private value towards the perceived social value of any patentable invention which might result. This could hardly fail to make investment in R&D more attractive, and result in more inventions. Thirdly, the inventions bought by the government and put into the public domain could then be expected to be developed by several firms by incremental changes along different trajectories. More and better products would then be brought to the market, more quickly and at progressively lower prices, to the benefit of the general public. Fourthly, since competitors could obtain access to the originator's information by paying the prescribed fee, they would no longer have to invest in research to "invent around" a valuable patent. These resources could be put instead into original research. Finally, virtually all of the great waste of resources involved in patent litigation could be expected to be eliminated.

However, how is the value of a patent for buy-out purposes to be established? Kremer proposes a sealed-bid auction run by the government.[37] After scrutinising the bids in this, it would then offer to buy some (perhaps most) randomly selected patents for a multiple of what was bid for them. This multiple, Kremer suggests, should be between two and three to make the payment reflect the patent's assumed social value. The owner of the patent could accept or reject this offer, and if he or she accepts, the patent would be extinguished and its information would be freely available to all to use. The remaining patents would go to high bidders at the auction in the usual way. The balance between the proportion of patents which would be bought out and those which would remain as private monopolies after an auction would depend upon what proportion of actual sales to private bidders it would take to get bidders to make realistic offers. Obviously,

[36] E. Mansfield, M. Schwartz and S. Wagner, "Imitation Costs and Patents: An Empirical Study" (1981) 91 *Economic Journal* at pp.907–918.

[37] Kremer, pp.1146 *et seq*.

they will only do this if they think that there is a reasonable chance of their bid being accepted.

All of these advantages are both substantial and plausible, but of course there would need to be provisions to prevent collusion to inflate the apparent value of patents, and the payments would require very considerable subsidies by government.[38] However, governments are in fact increasingly subsidising R&D, and the auction method of distributing subsidy both leaves decisions as to what projects are to be undertaken to the widest possible group of investors, and increases the attraction of such investment to them.[39]

Biotechnology patents (including of course those which have any bearing on plant breeding) are obvious candidates for such a "buy-out" procedure. It has been argued that such patents can be an impediment rather than a stimulus to innovation.[40] Indeed, there are even persuasively argued calls for the US Supreme Court decision in *Diamond v Chakrabarty* and its effective counterpart in Europe, Directive 98/44/CE, which make legal protection of biotechnological inventions possible, to be reversed.[41]

Some plant pedigrees involve more than 50 parents, and it is very difficult to establish the importance of any single trait in the overall performance of a variety. Since a patent is a property right, if a patentee flatly refuses to grant a licence to a competitor, nothing can be done at present. When breeders need permission to use the germplasm of several originators in a programme (known in the industry as "royalty stacking"), then, if patent protection is determining, the refusal of a single one of these to grant a licence could make an entire project very difficult or even impossible. In such situations, Kremer's buy-out proposal is one way of drawing the sting from the infiltration of patent principles into protection for plant varieties, at least in developed countries. In poorer ones, similar buy-outs of patents which had used material transferred under the provisions of the International Treaty on Plant Genetic Resources for Food and Agriculture could designate a proportion to be distributed according to that Treaty's mandate.

In a later article, with Zwane,[42] Kremer has applied his thinking specifically to the problem of getting more benefit from research in areas which are intended to benefit poorer tropical countries. These authors point out that it is not enough to produce new varieties which are improvements; they must be improvements which native farmers can and do adopt. As they put it, "[g]overnment-funded 'push' programs have created outputs that are often subject to low adoption rates".[43] They advocate, instead, "pull" programs which would reward specific desired products. These would provide incentives to producers to invest in all the steps along the way to adoption,

[38] Kremer, p.1157.

[39] There have recently been public auctions of patents in the United States, but it is too early to say if they will become a regular feature of the patent system there.

[40] See, e.g. M.A. Heller and R. Eisenberg, "Can patents prevent Innovation? The anti-commons in biomedical research" (1998) 280 *Science* at pp.698–701.

[41] See N.P. de Carvalho, "The problem of gene patents" (2004) 3 *Washington University Global Studies Law Review* 3 at pp.701–753.

[42] Kremer, Michael and A.P. Zwane, "Encouraging Private Sector Research for Tropical Agriculture" (2005) 33 *World Development* 1 at pp.87–105.

[43] Kremer, Michael and Zwane, p.100.

which "push" programs cannot match. Although the suggestion suffers from the disadvantages discussed above in relation to prizes, so much foreign aid has led to so little improvement in the lot of poorer countries that anything seems to be better than present arrangements.

CONCLUSION

Existing plant variety protection has three particularly valuable characteristics. First, unlike patents, UPOV is a system which protects innovations, not inventions; secondly, because it is a comparatively new *sui generis* system, steps to improve it are not constrained by the venerable tradition and scale of vested interests which make reform of the patent system so difficult; and thirdly, it escapes the rigidity now imposed by international agreement on all other kinds of intellectual property. None of these advantages, of course, makes it an easy task to bring about reform in any situation where broad international agreement is required. It is important that reforms produce systems that "are accessible to all, and not merely the legally literate few".[44]

It will be recalled that Art.27(3)(b) of the TRIPs agreement allows plant variety protection to be "either by patents or by an effective *sui generis* system or by any combination thereof". In using the freedom which comes with this Article, those who are responsible for setting the conditions for protecting the results of R&D for new plant varieties in advanced countries are free to adopt radical changes if they wish. Poorer countries may find that some version of "patents without monopoly", as discussed above, or even a combination of components from all three versions, could also be helpful in protecting their natural resources and traditional knowledge.

[44] Llewelyn, Margaret and Mike Adcock (2006) *European Plant Intellectual Property* 529. Oxford and Portland, Oregon, Hart Publishing.