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► **To cite this version:**

Maurice Cassier. New ‘enclosures’ and the creation of new ‘common rights’ in the genome and in software. *Contemporary European History*, 2006, 538. halshs-01964787

HAL Id: halshs-01964787

<https://shs.hal.science/halshs-01964787>

Submitted on 23 Dec 2018

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New 'enclosures' and the creation of new 'common rights' in the genome and in software

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Scott Kieff, ed. *Perspectives on Properties of the Human Genome*. Amsterdam: Elsevier Academic Press, December 2003. ISBN 0-12-017650-5, 538 pp., € 126

John Sulston and Georgina Ferry, *The Common Thread. A Story of Science, Politics, Ethics, and the Human Genome*. Washington: The Joseph Henry Press, 2002. ISBN 0-309-08409-1, 310 pp., € 12.30.

Kevin Davies, *Cracking the Genome. Inside the Race to Unlock Human DNA*. Baltimore: The Johns Hopkins University Press, 2002. ISBN : 0-8018-7140-9, 327 pp., € 18.

Bronwyn Parry, *Trading the Genome. Investigating the Commodification of Bio-Information*. New York: Columbia University Press, 2004. ISBN 0-231-12174-1. 319 pp., € 37.50.

Magali Franceschi, *Droit et marchandisation de la connaissance sur les gènes humains*. Paris: CNRS Editions, 2004. ISBN 2-271-06200-4, 247 pp., € 25.

Richard M. Stallman, *Free Software, Free Society. Selected Essays*. Boston: GNU Press, 2002, ISBN 1-882114-98-1, 220 pp., € 18.

Special Issue on Open Source Software Development, *Research Policy* 32 (2003), Elsevier Science.

Recently a number of works in or combining the disciplines of economics, law and economic anthropology have compared the extension of intellectual property rights over genomes (including the human genome) and software to the enclosure movement which led to the privatisation of common land in England and France beginning in the seventeenth century. Rights of exclusive ownership are now being extended to objects or property which until recently were considered inappropriable: in 1997 the human genome was declared ‘a common heritage of humanity’,¹ and in 1983 the FAO declared that plant genetic resources were ‘a common heritage of mankind’. In the 1960s and 1970s, intellectual tools such as software were still quite freely shared among communities of programmers.² The recent strong trend towards privatising both software and living matter, as seen from the rapid growth in patents and the proliferation of private repositories of biological materials and of private databases, is now seen by many analysts as threatening a copyright or patent right overload which may impede the advancement of science and the progress of innovation. Two jurists, Rebecca Eisenberg and Michael Heller, have coined the phrase ‘the tragedy of the anticommons’³ to describe a situation where biomedical innovation is hampered by excessive intellectual

property rights over biological research tools. However, this trend towards privatisation is neither uniform nor unilateral. It has encountered strong resistance from the public domain and from 'open science' rules and even the creation of new 'commons'. Among notable advocates of the 'commons' are John Sulston, winner of the Nobel Prize for Medicine in 2002 and contributor to the public consortium that sequenced the human genome (the Human Genome Project) and Richard Stallman, a programmer at MIT's Artificial Intelligence Laboratory who created the movement for free software and free software licences in reaction to the expansion of proprietary software in the 1980s.

This re-drawing of the science and software zones of the intellectual property map is still very much in progress, with active participation from scientists and programmers who, like Sulston and still more Stallman, are helping to re-define copyright rules through their work in science and technology. I shall attempt to trace this history using evidence from witnesses, including Sulston and Kevin Davis on the sequencing of the human genome, Stallman's essays working towards the definition of a new kind of ownership in the form of 'free' software, and four books or journals which seek to mesh together economics, law and anthropology. Magali Franceschi's *Droit et marchandisation de la connaissance sur les gènes humains* offers a jurist's perspective on the shifts in the legal concept of the patent in response to new ways of generating knowledge and the interaction of science and the private market in the field of genomics. *Trading the Genome*, by the geographer and anthropologist Bronwyn Parry, looks at the changing status of repositories of genetic resources, from common property to marketable asset, with special attention to contracts for collecting and research. *Perspectives on Properties of the Human Genome*, edited by Scott Kieff, brings together the thoughts of legal experts and economists about an appropriation which has been dubbed the 'tragedy of the commons' (or 'anticommons'), with some suggestions for practical solutions, e.g. changing the scope of patents or gathering them into 'patent pools'. While the focus of

the book is on economics and law, it begins with a statement by a biologist, Amanda Chakrabarty,⁴ who gave his name to a bacterium which he developed in the laboratories of General Electric and which marked a turning point in the patenting of living matter in the early 1970s. The special issue of *Research Policy* devoted to open source software development traces the history of the movement since the 1970s and strives to explain its economic impact and the reasons behind it. Georg von Krogh and Eric von Hippel draw on the work of ethnographers to explain the appearance of communities of open source software programmers, together with economic analyses of confrontation and co-operation between open-source and proprietary software.

The first part of the article deals with this latter-day enclosure movement, with particular attention to legal mechanisms for copyrighting or patenting genomes and software, something which is richly documented and extensively discussed in the works under review. The second part returns to the idea that an excess of privatisation has led to a ‘tragedy of the anti-commons’. The third part looks at the construction of new commons by research consortia seeking to promote some sort of collective ownership of genomes, and at ‘General Public License’ (GPL) that has been developed and implemented by advocates of free software. Part four examines what forms of governance are best suited to the constitution and management of common property by communities of scientists or programmers dealing with a single object, be it a piece of software in course of development or the genome of a living organism. I shall show that such communities are tending increasingly to exploit the law of contract and intellectual property in order to define and manage the ‘commons’ in the context of volunteer communities and consortia that involve both public and private institutions, and sometimes even national governments.⁵

1- Genomes, software and the ‘enclosure movement’

Legal appropriation of genomes and software depends on the extension of patentability to new things – human genes isolated and replicated in the laboratory, living organisms that have been modified, or merely removed from their natural environment and purified; mathematical abstractions hitherto not thought patentable – and on a huge rise in the number of contracts limiting access to repositories of biological materials and to medical and scientific databases. In combination, patents and contracts are used to define proprietary assets and trade them on new markets that deal in science, living material, health and agronomics. Francheschi, the jurist, pays particular attention to the evolution of the legal concept of the patent as applied to science and living matter; Parry, the anthropologist, examines the contracts used to monopolise genetic resources; Eisenberg, another jurist, looks at transfer licences used to move research tools between universities, biotech companies and pharmaceutical laboratories.

Using patent or contract law to control biotechnological innovation is not a new idea, as I have shown elsewhere in relation to appropriation by Louis Pasteur.⁶ Daniel Kevles, in his history of life patenting in the US, points out that plants were being patented in the 1930s.⁷ However, patent applications increased by leaps and bounds between the 1970s, when the first patents were granted for human genes transferred into bacteria with the intention of using biotechnology to produce proteins for pharmaceutical use (starting with insulin),⁸ and the 1990s, when tens of thousands of patents were sought for genes or gene fragments that might have medical potential. One important trend-setter was the patent granted to the National Institute of Health in 1991 covering several thousand partial gene sequences identified by a scientist, Craig Venter, who went on to dominate genome research in the private sector.⁹ What was innovatory about this patent was its object – fragments of gene sequences to be used as research tools to identify further genes – and the startling breadth of its claims, which were for ownership not only of the partial sequences but also of any complete genes which might be

identified using those sequences. Another remarkable set of patents was granted to Myriad Genetics in 1994/5 for the genes which predispose to breast cancer.¹⁰ Again the claims were very broad, covering the gene and its protein as products together with any biological materials in which the gene might be inserted or expressed (e.g. cells, transgenic animals used to screen medicines) and also any potential medical applications, including genetic diagnosis and potential gene therapies. The granting of patents for human genetic sequences, whether partial or complete, depends on a series of paradigm shifts in patent law, most importantly, perhaps, the blurring of the distinction between discoveries, which are not patentable, and inventions, which are. 'Invention' is no longer defined in terms of artificial creation – which might extend to a new variety or a new genetically modified organism – but of isolation – extracting something from its natural environment and purifying it. Indeed, the European Directive on legal protection of biotechnological invention¹¹ insists that '[an invention based on] an element isolated from the human body or otherwise produced by means of a technical process [including a sequence or partial sequence of a gene]* [...] is not excluded from patentability, even where the structure of that element is identical to that of a natural element.' Sulston re-examines these new patentability criteria, pointing out that it is only necessary to isolate and clone a human gene in order to make it patentable.¹² Since a gene cannot be identified unless it is first isolated and cloned, this means that all human genes are potentially patentable if they fulfil the criteria of usefulness and industrial application. Moreover, insofar as all laboratory work substantially consists of isolation, all laboratory products become patentable, even if they are really works of nature which human activity has done no more than reveal. The extreme breadth of these patents is due to the fact that they are product patents which, like the more familiar patents on chemical products, confer absolute protection of all uses and applications of the gene, even if they are not described in the patent in question and were never envisaged by the patentee. These product patents on genes are considerably

broader than the early 1970s ones for human gene sequences that were included first in vectors and later in bacteria used to produce medicinal proteins. The patent on the procedure for producing recombinant insulin claims the human insulin gene inscribed in a certain biological construct, which is part of a biotechnological procedure; it does not directly claim the insulin gene as a product.¹³ Sulston also points out that the monopoly conferred by these gene patents is all the more absolute because it is impossible to invent a new gene that predisposes to the disease linked to the patented gene, whereas a chemical product patent can be circumvented by inventing a similar molecule. Hence it is impossible for any user to get round a gene patent.

Privatisation is also spreading further than the actual patent, to include repositories of genetic material made to assist gene research. A notorious example is the privatisation of medical and genetic data on the population of Iceland, which is exploited commercially by a private medical genetics company known as deCODE Genetics.¹⁴ The Icelandic government brought this about by putting two bills through the Althing, the first granting deCODE an exclusive twelve-year licence to exploit the medical databases of the Icelanders, the second authorising it to exploit the ensuing DNA repository. When appealing for funds on the financial markets deCODE described itself as a ‘population-based undertaking’, though it was based more particularly on the commercial exploitation of the Icelanders’ genetic profile, which is believed to be exceptionally homogeneous. Many similar licences have been granted since to exploit other populations, such as the Tongalese: the Tongan Ministry of Health has signed a contract with an Australian biotech company.

Privatisation extends to both physical DNA repositories and biological databases. Another start-up model has emerged, based explicitly on the marketing of genetic information. The archetype was launched in 1998 by Craig Venter when he set up Celera Genomics in association with Perkin Elmer, a manufacturer of scientific instruments. Perkin

Elmer had developed an automatic genomic sequencer and was anxious to control the market not only for the sequencer but also for the genetic sequences that could now be read in large numbers. Venter maintained that Celera Genomics was intended to be not just another pharmaceutical company but an ‘information company’ selling data to pharmaceutical laboratories.¹⁵ The commercial value of private databases depends on commercial secrecy, the originality of the proffered information, and their lead over other data in the public domain. Access to commercial databases is restricted by licence, either exclusive, if granted to a single user, or non-exclusive, if acquired by more than one firm. Celera Genomics’ data retention strategy brought it into frequent conflict with the Human Genome Project public consortium, whose policy was immediate release of any sequences it produced.¹⁶ Repeated attempts to reconcile the two organisations and so accelerate the deciphering of the human genome failed despite US government support.

The tendency towards exclusivity, in which universities have also played their part,¹⁷ is now so strong that some authors are describing these restrictions on the free availability of scientific information as ‘new enclosures’ of the ‘intellectual commons’.¹⁸ As with the original enclosures, private ownership is represented as a way of ensuring good governance of resources to maximise the production of wealth – the wealth being, in the modern case, intellectual innovations or new therapies. Here it is worth recalling that the theory of property rights developed by the economist Harold Demsetz¹⁹ applies the ‘tragedy of the commons’ idea to science: ‘If a new idea is freely appropriable by all, if there exist communal rights to new ideas, incentives for developing such ideas will be lacking’. In the modern scenario, this would favour granting exclusive rights over genomes or software in order to encourage inventors and programmers to develop new creations or inventions. Several authors have pointed out that the science model does not constitute a good parallel to the old commons. In the first place, ‘over-grazing’ of the intellectual commons is not much of a problem – on the

contrary, it is under-use which would best justify their appropriation by private interests²⁰ – and in the second place, not all the factors that encourage the development of science, including those internal to the scientific community such as priority of publication, are market-oriented. We might add that the concept of ‘intellectual commons’ does not account for every aspect of the present situation insofar as privatisation affects not only knowledge, text and intellectual tools such as software, but also repositories of actual physical things such as DNA molecules, plant mutations and micro-organisms, which cannot be subjected to the same conceptual models as pure ‘knowledge’ because they are not infinitely expansible. It is of course easy to duplicate or synthesise a gene in the laboratory, but the total number of genes in any one organism cannot be expanded. Privatising a gene constitutes a particularly powerful monopoly because a gene, as an element of nature, is unique.²¹

2- The encumbrance of private ownership: are we facing a ‘tragedy of the anti-commons’?

As exclusive rights to genomes proliferate and become more complex, two jurists have dubbed this emerging model of private ownership ‘the tragedy of the anticommons’.²² In contrast to the ‘tragedy of the commons’, identified by Garrett Hardin in 1968²³ as being due to over-grazing of common pastures by herdsmen all of whom had equal rights to a scarce resource, the tragedy of the anticommons describes a situation of *under*-use of a resource owing to excessive propriety rights. In the former case, no user had the power to exclude any of the others; in the second, too many have that right: ‘Privatization can solve one tragedy but cause another.’²⁴

With reference to genomics and biomedical research, Heller and Eisenberg discern a shift from a ‘commons model’, whereby governments finance pre-commercial research and it is widely available in the public domain, to a privatisation model, whereby scientific institutions take out patents for results which would previously have been made freely available. Exclusive ownership is now extending to ‘research tools’²⁵ and the old academic model of open science is tending to erode: ‘What was once a collective enterprise, in which discoveries were acknowledged but their results freely shared, is now frequently constrained by the demands of commercial competition’ (Sulston, Preface to *The Common Thread*, p. ix).

What are the observed facts here which might lead to a crisis of exclusivity, the ‘tragedy of the anticommons’?

First and foremost, the granting of patents for fragments of a gene, or different versions of the same gene – e.g. BRCA2, which pre-disposes to breast cancer and of which one version is patented by Myriad Genetics and the other by the Cancer Research Campaign, a charitable trust – is creating uncertainties and potential legal disputes. In fact, the two owners of BRCA2 are currently in dispute before the European Patent Office.

Secondly, the granting of patents over partial gene sequences again creates potential dependencies and conflicts insofar as these patents claim to cover complete genes which are yet to be discovered. The holder of a patent for a research tool (a gene with pharmaceutical potential) may claim part ownership of the final product (the pharmaceutical itself) – though the scope of such patents has recently been curbed by courts which have held that this type of claim is invalidated by insufficient description.²⁶

Thirdly, the exchange of research tools, even between public research laboratories, is now restricted by material transfer agreements which frequently grant the proprietor of such tools rights over any inventions developed by the end-user. In other words, the end-user’s research is shackled by the owner of the upstream research tool. Eisenberg points out that this

situation might prove very costly for a lab. working on medicines that require multiple research tools, all of whose patentees might claim a share in the end product.²⁷

Fourthly, the anticommons might be brought about by the frequent need, in pharmaceutical research and genetic medicine, to use a number of different patented techniques or objects in order to develop a particular product or technique. One lawyer specialising in industrial property has shown that a gene therapy project may involve obtaining literally dozens of licences from different patentees, a situation he summed up concisely as a ‘DNA nightmare’.²⁸ Obviously the cost of negotiating rights, and the final royalties total, may turn out to be prohibitive. Specialists in intellectual property are now asking if it is possible to lump together proprietary rights in order to develop ‘DNA chips’ which could be used to test hundreds, if not thousands, of different genes. In that context, the present fragmentation of proprietary rights to genes would simply be untenable.

Fifthly, Eisenberg and Heller point out that negotiations over proprietary rights will be complicated by the divergent interests of leading biomedical researchers and the variety of information available to them. New firms having control over research tools strive to maximise income from pharmaceutical laboratories, which retaliate by using every possible strategy to put such tools in the public domain.²⁹ As for the universities, the authors consider that they are ill-equipped for such negotiations and that scientists tend to over-estimate the value of patents which are far upstream of actual innovations.

Several of our authors suggest ways of preventing or managing this encumbrance of intellectual property. Heller and Eisenberg, along with Edmund Kitch,³⁰ have suggested that proprietary rights could be shared by creating ‘patent pools’, such as have in fact been set up for biotech patents by certain scientific institutions in the US and Europe. This benefits both patentees, who are more likely to attract licensees if their product is included in a larger and more coherent basket of technologies, and users, who can acquire multiple rights from a

single negotiator. Sulston also proposes restoring the balance between private and public ownership by tightening the rules for patentability so as to exclude ill-defined gene sequences, or even genes of any kind. As regards software, Stallman suggests slashing the duration of copyright to ten years so as to encourage innovation. Sulston also makes a third suggestion: systematic exploitation of obligatory licences to prevent bottlenecks in genetic research. In this case, the patentee would be remunerated but would lose his exclusivity.

Two economists, John Walsh and Wesley Cohen,³¹ have argued that the anticommons will never come about: not because there is no tendency in that direction but because the biomedical researchers they have questioned have found ways to get round copyright, e.g. by exploiting research exemptions, infringing patents or using public databases, or simply by getting licences for the research tools they need. However, the authors agree that it is hard to get round a patent on a therapeutic or diagnostic target, and that the negotiations required by this inflation of private rights bear a social cost.

3 – The public domain fights back: the creation of new ‘commons’

Sulston and Stallman both describe communities of scientists and programmers/engineers who were studying living organisms, or developing software, in the 1980s, either before or during the great expansion of intellectual property. Their experience of this expansion, and the way it challenged commonality in the domains of science and software, convinced them to fight back and develop rules for the dissemination of knowledge that would preserve or enlarge the ‘commons’.

Sulston traces the formation of an academic community committed to mapping and sequencing the genome of a nematode worm that had been used as a model in molecular

biology since the 1960s. This was an academic goal with no immediate commercial potential, financed long-term out of the public purse. The researchers exchanged their findings at meetings of the ‘worm community’.³² This early 1980s project to map the nematode genome stimulated the emergence of a scientific community, the ‘worm people’, which encouraged the free circulation of biological material and of the scientists themselves. The map was a shared research tool available to all scientists who were trying to locate a particular gene in any laboratory in the world. In return, the mappers improved their work using information from these researchers: ‘it was a virtuous circle’. This cumulative creation of knowledge was greatly assisted by the policy of immediate release of mapping data: ‘We realized that if we waited until the map was complete before we published it, we would be sitting on a lot of information that was of value to the community . So almost from the start we began to make the mapping data available electronically over the predecessor of the internet.’

In 1991 Sulston was asked by Leroy Hood of CalTech, founder of a company that manufactured automatic sequencers, to head a commercial sequencing firm in Seattle. Uncertain whether public money would be available for the continued sequencing of the nematode genome, Sulston met with a private investor, Frederick Bourke, who was interested in this field. The negotiations soon foundered on the question of patenting gene sequences, which Bourke insisted on and Sulston refused. This public–private confrontation became much more intense when the genome to be sequenced was the human one. In 1992 another investor, Wallace C. Steinberg, poached Craig Venter from NIH and set him up in a non-profit-making sequencing organisation, TIGR, which was in turn linked to a for-profit organisation, HGS (Human Genome Science). Venter was left free to choose his own direction of research and to publish, but at a later date. This meant that the commercial firm would have exclusive access to Venter’s data for six months before publication, or twelve months in case of a potential new medicine.

A number of genome companies were set up in the early 1990s, including Incyte and Myriad Genetics, to look for genes of potential medical interest, patent them and sell the rights to pharmaceutical companies. In 1994/5 the scientific community was outraged when Myriad applied for a patent on genes BRCA1 and BRCA2, which pre-dispose to breast cancer. The Human Genome Project public consortium retaliated by adopting a rule requiring immediate release of the raw genome sequence, which was incorporated in the Bermuda Principles of 1996.³³ These principles were a deliberate attempt to take the wind out of the sails of patent applicants. By releasing the sequence immediately, day by day as it was read by the sequencers, without waiting until it could be finished and annotated, the team aimed to forestall any patent applications for the sequence itself: 'Open access and early release mean that anyone in the worldwide biological community can use those data and turn them into new inventions that can be patented. But the sequence itself in its raw form when publicly released becomes unpatentable' (*Common Thread*, p. 146). In reality, the Bermuda Principles do not preclude patenting genes because it is only the primary sequence that is in the public domain. The declaration by the Human Genome Organization (HUGO) on gene patenting, adopted subsequent to the Bermuda Agreement, confirms that genes of potential medical interest identified using the primary sequence are patentable so long as their biological function has been identified.³⁴ Patent offices will accept novelty and inventive step for genes which have been isolated and annotated using material from the raw sequence. Despite this significant limitation, the Bermuda Principles are a way to stem the flood of patents on undefined raw sequences and limit the inroads of commercial secrecy into genetic sequence databases. A number of governments were reluctant to accept this curb on patentability. In 1997, the German research team's policy of temporarily reserving sequences came in for some criticism: it was imperative that the early release principle should be adopted by all partners so as to encourage co-operativeness. The Bermuda agreements set up a mechanism for

collaborative generation of the sequence in various countries and various large public or non-profit-making genomic laboratories.³⁵ Areas of the genome had to be apportioned in such a way as to avert rivalry and duplicated effort. All contributors were given a complete copy of the biological material to be sequenced, and quality standards were set by the consortium as a whole.

In May 1998 the community was thunderstruck by the announcement that a private company, Celera Genomics, had been set up under the aegis of Perkin Elmer, a manufacturer of automatic sequencers, to sequence the human genome before the date originally envisaged by the public consortium. How fast the sequencing could be done became the key element in this competition between the private and public sectors: the commercial value of the sequence to the private company depended chiefly on the lead it could acquire over its public rival and the patents it could then obtain over genes of medical interest. Celera was seeking to outpace its rival and demonstrate that the sequencing of the human genome was best left to private investment; the public consortium would do better to turn its attention to the genomes of the mouse and other model organisms. Two days after the launch of Celera Genomics, the Wellcome Trust announced that it was doubling its support for the consortium and would oppose any applications for gene patents which it considered undeserved. In March 2000 Bill Clinton and Tony Blair threw their weight behind the consortium's policy of immediate release of the raw human genome sequence, though they acknowledged the patentability of 'gene-based inventions'. In 2002 the competition was resolved when Celera Genomics converted from an information-based company to a pharmaceutical development company. Before this, in February 2001, the consortium and Celera simultaneously released their rival versions of the human genome sequence. By releasing the raw sequence into the public domain, the consortium had ruined Celera's commercial project, though Celera tried to salvage it by imposing rigorous conditions on publication. Defying the rules of scientific

publication, which required gene sequences to be released into public databases as soon as they had been published in a scientific journal, Celera persuaded the journal *Science* to make an exception, keeping the sequence between four walls and subjecting it, when released, to a restriction on downloading by academic researchers, while industrial users had to apply for a licence. Another bone of contention was the probability that Celera had helped itself liberally to the open-access data released by the consortium, incorporated them into its own data and then sold them. All in all, however, the public consortium had successfully defended the model of scientific community against the trend towards privatisation: ‘I think we in the international sequencing consortium succeeded in doing that as far as the raw sequence was concerned’ (Sulston, *Common Thread*, p. 270). Sulston was anxious to defend the genome’s status as common property for a number of reasons. First, he wanted to preserve the ‘open science’ model, both to safeguard the commonality of values³⁶ and because it is an efficient way of creating knowledge, since the sequences are accessible to and usable by any scientist; secondly, to preserve the genome’s status as the ‘common heritage of humanity’.

Sulston also supports Oxfam’s campaign to facilitate access to medicines in the third world and permit the manufacture of generic medicines in India, Brazil and Egypt in opposition to the tightening of intellectual property rights over pharmaceuticals enshrined in the TRIPs agreement (Trade-Related Aspects of Intellectual Property Rights). Thus his commitment to common ownership extends to health and medicine.

The ‘free’ software model, particularly as embodied in the General Public License, again originated with communities, in this case communities of software engineers and scientist programmers which sprang up in the 1960s and 1970s.³⁷ Some, like Richard Stallman (then at MIT) were academics, others worked in industry, but all made their own software freely available, modified programs made available to them, and re-released those programs once modified: ‘Whenever people from another university or a company wanted to port and

use a program, we gladly let them. If you saw someone using an unfamiliar and interesting program, you could always ask to see the source code, so that you could read it, change it, or cannibalize parts of it to make a new program' (Stallman). This habitual exchange and co-operation was not confined to the academic fringe: it was integral to important public developments such as ARPANET, the proto-internet devised by the US Defense Advanced Research Project Agency. This 'software sharing community'³⁸ was particularly well exemplified by MIT's Artificial Intelligence Laboratory. In the early 1980s MIT granted a licence for a software package developed by the Laboratory to a commercial firm which promptly attempted to block access to the source code, preventing other programmers – including the very MIT engineers who had developed it – from using it to develop new software. Outraged by this policy of blocking free access to source codes, which was becoming a general trend at the time, in 1985 Stallman decided to quit MIT and set up the Free Software Foundation dedicated to inventing and disseminating rules to promote free access to software and free co-operation among programmers.

Stallman laid down four basic principles for free software.³⁹ First, users must have the freedom to run the program, for any purpose. Secondly, users must be free to adapt the program to their needs. Access to the source code is a precondition for this. Thirdly, users must be free to redistribute copies, with or without payment. Fourthly, users must be free to distribute improved versions of the program so that the whole community benefits. These principles are embodied in the General Public License, which exploits the programmer's copyright not in order to restrict possible uses of the software – to run, copy, modify or redistribute it – but to guarantee unrestricted use of it. Stallman dubbed this topsy-turvy use of copyright to create common instead of private property 'copyleft': 'instead of a means of privatizing software, it becomes a means of keeping software free'.⁴⁰ The General Public License entitles the licensee to run the software, examine the source code, modify the

software and redistribute modified and unmodified versions of it. A key feature of the GPL is that it gives the user these rights of use, modification and redistribution while forbidding him to restrict use in his turn: ‘the crucial freedoms that define free software are guaranteed to everyone who has a copy; they become inalienable rights’ (Stallman). This is a powerful mechanism for preventing the alienation of the ‘commons’, developed by Stallman in the cause of managing the interface between free and proprietary software. How can a user be stopped from appropriating free software after having modified it, thus removing the improved version from the commons to the detriment of all other users? Copyleft is the answer: ‘With this self-perpetuating clause, the General Public License not only establishes a commons, but a fence that protects that commons.’⁴¹

In this way, commons regulated by the GPL are better armed against privatisation than ‘public domain software – software that is not copyrighted’, because any modified version of the latter is vulnerable to appropriation. Stallman contrasts this situation with that of software released under the GPL, which cannot be appropriated even after modification: ‘GNU⁴² is not in the public domain. Everyone will be permitted to modify and redistribute GNU, but no distributor will be allowed to restrict its further redistribution.’ Compare these hopefully inalienable commons with the fate of the gene sequences produced by the Human Genome Project, which were released on public databases and which Celera Genomics freely combined with its own data so as to enlarge its proprietary database: ‘...Celera was going to combine the publicly available data with its own in the commercial product it produced, and the company needed no agreement from us to do this’ (Sulston, *Common Thread*, p. 211). This borrowing of genome data to be sold under an exclusive licence would have been impossible if the data had been released under the GPL.

Some contributors to the Human Genome Project did consider the possibility of using the free software principle to keep their data out of Celera’s hands: ‘As talks with Celera

proved less and less likely to get anywhere, Tim Hubbard and others began to work on the idea that we should use the open source model to protect our data' (ibid., p. 212). The idea was to release HGP data on to public databases along with a set of guidelines permitting all users to use them for research and product development and redistribute them in any form, but not to impose new restrictions on the use or distribution of the sequence. The Wellcome Trust's legal expert produced a draft licence, but it met with determined opposition from public databases, which complained that it violated the principle of free and unrestricted use of data in the public domain. They pointed to private companies such as Incyte that had for years been including public data in commercial private databases, without arousing the slightest opposition. There was also opposition to the idea that depositors could impose their own conditions on the use of public databases. In the end, the HGP scientists dropped the whole idea of open source licensing for fear of endangering the principle of free and unconditional use of gene sequences by both universities and industry. A few years later Hubbard revived the idea and applied the GPL principles to another genome consortium, the International HapMap Project.

4- Governance and regulation of the commons

In my view, the main difference between the new 'commons', created by the open source software movement and genomic research consortia, and earlier exchanges among research biologists and communities of programmers in the 1960s and 1970s is that the former are more highly organised and more legally aware. The free software movement produced the Public General License and its numerous variants. Genome consortia have produced a number of charters, guidelines, consortium agreements and licences, and common ownership models for results. These groups have exploited the notion of intellectual property with considerable

sophistication, sometimes turning it on its head in order to defend the commons, as with ‘copyleft’ or the systematic patenting of genes which are then released into the public domain, as with the SNP consortium set up in 1999 by an alliance of pharmaceutical firms and leading genome research centres. This enthusiasm among scientists and programmers for creating new institutions, sometimes in collaboration with legal experts, suggests a trend towards self-government among certain groups of scientists and engineers, inspired by an ethic and model of commonality in opposition to the trend towards privatisation that began in the 1980s. Not all these communities consist solely of private individuals bound together by reciprocal links and the exchange of knowledge: free software and open source movements⁴³ now tend to include large public bodies and industrial firms interested in the model. The genome consortia include large public research agencies and not-for-profit foundations like the Wellcome Trust, as well as some governments anxious to extend the regime of common property to things considered essential to the public weal, such as the sequencing of the human genome.

The trend, then, is towards ever tighter organisation of the commons. More frequent recourse to law and the establishment of specialist bodies to govern the commons – foundations or charities set up to develop free software – has not replaced the old reciprocity between scientists and programmers; rather, new layers of rules and regulations are piled one on top of the other in order to better regulate common space and common property.

With reference to molecular biology, Sulston describes the progressive organisation of the ‘worm people’s’ community which analysed the nematode gene in the 1970s and 1980s. It was an informal network of scientists co-operating without any formal agreement, but their conduct was nonetheless tightly regulated on a ‘gift economy’ basis – a principle often invoked by students of this kind of informal co-operation.⁴⁴ Historians of science have revealed the reciprocal exchange of know-how and research tools within the network of laboratories set up by the American geneticist Thomas Hunt Morgan in the 1930s to complete

the genetic mapping of the fruit fly.⁴⁵ Up to a point, these rules for the pooling of data resemble the ‘scientific communism’ described by Robert Merton in his ground-breaking article on the ethics of science.⁴⁶

In 1984 Jean Dausset and Daniel Cohen set up the Centre d’Etude pour le Polymorphisme Humain (CEPH), which, as mentioned by Sulston in his study of human genome sequencing, paved the way for a tighter organisation of scientific co-operation and a tighter definition of the commons. The CEPH had its own charter laying down the rules for laboratories wishing to join the CEPH network, including the conditions for access to and use of research tools and derived knowledge. The network depended on a DNA pool from thirty French and American families which was made freely available to all member labs, on condition that they communicated their results to CEPH before publication. The charter defined two degrees of accessibility to data: the first degree involved a collective database (the CEPH collaborative database) accessible only to members of the network; the second, the ‘CEPH public database’, was open to the entire scientific community. Collective data had to be placed on the public databases after a maximum of two years. These rules for a ‘service we intend to be universal’⁴⁷ worked very well insofar as they helped generate the first genetic map of the human genome, but the CEPH proved incapable of resisting the pressure towards privatisation of DNA repositories. In 1994 the organisation was shaken to the core when an exclusive licence for a DNA repository assembled by one of its scientists was granted to a private genomics company, Millennium Therapeutics.⁴⁸ In fairness it must be said that the CEPH charter of 1984 did not concern itself with the law of intellectual property.

The Bermuda Principles drafted by Sulston in 1996 and the HUGO⁴⁹ Statements were expressly designed to curtail patenting of genes and provide a common domain for the human genome sequence. They established the principle that the sequence, even if incomplete, should be released immediately in order to create prior art that could be invoked to deny

novelty to any patent applications. HUGO had a battery of lawyers specialising in intellectual property. Similarly, the Wellcome Trust's legal department came to the help of biologists seeking to prepare a licence modelled on the PGL. This defensive use of patents was again applied by the SNP Consortium, set up by eleven leading pharmaceutical laboratories associated with the USA's big genomics centres: its director, Arthur Holden, insisted that the aim was not just to publish the information, but first to use the patents system against itself in order to ensure availability of the data. Eisenberg describes other attempts to organise the sharing of research tools among academic institutions by means of non-exclusive cross-licensing: 'non exclusive grant back provisions might even be used to create a form of commons among institutions that share research tools, analogous to the copy left'.⁵⁰

Free software programmer communities have been very fertile in the production of rules to define and manage their commons, exploiting technological advances to facilitate organisation and deployment: 'In current Internet days, rapid technological advances in computer hardware and software [...] have made it much easier to create and sustain a communal development style at ever larger scales.'⁵¹ These communal software development projects are supported by various types of community, from individual volunteers⁵² to consortia of public research agencies and/or industrial firms.⁵³ Open source development is often initiated by an individual or small group who become the 'proprietors' or 'keepers' of the software and are responsible for managing it, including a contributors' address list. Admission to the community depends on voluntary contributions helping to test, or even write, the software. The project managers vet these contributions and may add them to the authorised version of the software. They are empowered to redistribute modified versions of the code. The community of developers and users is deeply involved in the protection of the free software, on the look-out for infringements of the GPL such as attempts to sell software derived from the free version without access to the source code. The Free Software

Foundation, created in 1985 to develop and disseminate the PGL, may sue to protect its own copyright, or act in support of other copyright holders.

Some projects set up a legally recognised institute or charitable foundation as copyright holder and defender. This transfer of rights generates a type of collective ownership which is vested in and managed by the foundation, but it is not universally approved by the free software community: certain enthusiasts for individual programmer autonomy have even described it as immoral.⁵⁴ As well as the PGL and collective ownership of software, some projects use trade marks to control and defend their commons.

The definition and management of these new commons is generating a vast number of private regulations – licences, principles, charters – issued by the creators of sequences or software, sometimes on the advice of lawyers representing a foundation or university, and has led to some ingenious uses of intellectual property, to keep the commons open instead of enclosing them. The social sciences have played their part by suggesting new ways to regulate and organise ownership by means of research consortia, patent pools and agencies exercising collective ownership.⁵⁵ This proliferation of rules for co-operation and the governance of the commons scarcely supports Hardin's theory of the 'tragedy of the commons' or Demsetz's theory of proprietary rights, both of which assume that communities are incapable of developing rules for common ownership and that only privatisation can ensure rational exploitation of scarce resources ('Freedom in a commons brings ruin to all' – Hardin). As far as the human genome and software development are concerned the contrary is true: rules for the creation and governance of commons are devised to overcome obstacles and avoid waste caused by the over-exploitation of proprietary rights. The justification for these rules is both ethical (for Stallman they safeguard programmers' freedom to co-operate, for Sulston they protect the ethics of science and the common heritage of humanity) and economic (the benefits of collective development in an open source or open science system, wider access to

intellectual tools and therapies, the elimination of monopolies on knowledge and medicines). The commons have been created to counter and compete with the extension of proprietary rights, or at times even to supplement them, for the common good.

¹ 'In a symbolic sense, it is the heritage of humanity' (article 1 of the Declaration on the Human Genome). The concept of 'common heritage of mankind', espoused temporarily by the legal committee preparing the UNESCO declaration, was eventually dropped despite vigorous protests from some of its members. The phrase 'common heritage of mankind' was far more restrictive than the version actually adopted, in that it could be used to oppose the patenting of genes. See B. M. Knoppers, *Le génome humain, patrimoine commun de l'humanité ?* (Montreal: Fides, 1999).

² See Stallman, *Free Software, Free Society*, and the *Research Policy* special number on free software, no. 32, 2003.

³ 'Can Patents Deter Innovation? The Anticommons in Biomedical Research', *Science* 280 (1998), 1. Their idea is extensively discussed in Kieff (ed.), *Perspectives on Properties of the Human Genome*.

⁴ A. Chakrabarty, 'Patenting Life Forms, Yesterday, Today and Tomorrow', in *Perspectives*, 3-11.

⁵ The Human Genome Project public consortium was the result of initiatives by research communities and political decisions by public research agencies, from non-profit-making research institutions to providers of government support.

⁶ M. Cassier, 'Appropriation and Commercialisation of the Pasteur Anthrax Vaccine', *Stud. Hist. Phil. Biol. & Biomed. Sci.* 36 (2005), 722-42.

⁷ D. Kevles, *A History of Life Patenting in the United States with Comparative Attention to Europe and Canada: A Report to the European Group of Ethics and New Technologies* (Office for Official Publications of the European Commission, 2002).

⁸ See Eisenberg in *Perspectives*, 209-30.

⁹ Venter's patent is described in detail in Davies, *Cracking the Genome*. The United States Patent Office rejected it in 1992 on the grounds that it was of doubtful utility; but in 1999 the USPTO granted a very similar patent to Incyte.

¹⁰ These are examined by Sulston in *The Common Thread*.

¹¹ EEC Directive 98/44, adopted on 6 July 1998. It was rejected by the European Parliament in March 1995.

* See articles 21 and 22 of the Directive – trans.

¹² Sulston, *Common Thread*, p. 269.

¹³ Eisenberg discusses the two types of claims in *Perspectives*.

¹⁴ See Davies, *Cracking the Genome*, chapter 6, ‘Treasures of Lost Worlds’, for company monopolisation of stocks of genetic resources.

¹⁵ ‘People think this is a biotech company. It’s not. It’s an information company’: Craig Venter, quoted in Davis, *Cracking the Genome*, p. 208.

¹⁶ Cf. Sulston, *Common Thread*, and Davies, *Cracking the Genome*.

¹⁷ Cf. J. H. Reichman, ‘Saving the Patent Law from Itself’, in Kieff (ed.), *Perspectives*, pp. 289-303.

¹⁸ See J. Boyle, ‘Enclosing the Genome: What Squabbles over Genetic Patents Could Teach Us’, *ibid.*, pp. 97-122.

¹⁹ ‘Towards a Theory of Property Rights’, *The American Economic Review* 57/2 (1967), 347-59.

²⁰ See Boyle, ‘Enclosing the Genome’, p. 98.

²¹ For a useful discussion of the twofold nature of bio-information – part physical, part virtual – see Parry in *Trading the Genome*.

²² Heller and Eisenberg, ‘Can Patents Deter Innovation?’

²³ ‘The Tragedy of the Commons’, *Science* 162 (1968), 1243-8.

²⁴ Heller and Eisenberg, ‘Can Patents Deter Innovation?’

²⁵ I. Cockburn, ‘O Brave New Industry, That Has Such Patents in It! Reflections on the Economic Consequences of Patenting DNA’, in Kieff (ed.), *Perspectives*, pp. 385-98.

²⁶ See R. Eisenberg, ‘Reaching through the Genome’, *ibid.*, pp. 209-30.

²⁷ *Ibid.*, p. 229.

²⁸ Thus J. Warcoin at the OECD seminar on ‘Genetic Inventions, Intellectual Property Rights and Licensing Practices’, Berlin, 2002.

²⁹ In 1994 Merck went into collaboration with a federal laboratory to develop a public database for partial gene sequences.

³⁰ E. Kitch, ‘Comment on the Tragedy of the Anticommons in Biomedical Research’, in Kieff (ed.), *Perspectives*, pp. 271-3.

³¹ ‘Patenting and Licensing of Research Tools and Biomedical Innovation », in S. Merrill, R. Levin and M. Myers (eds.), *Innovation in a Knowledge Based Economy* (Washington: National Academies Press, 2003).

³² Sulston, *Common Thread*, p. 32.

³³ Sulston gives a very detailed description of how these principles were drafted in *Common Thread*, pp. 144-6.

The Bermuda Principles were adopted by 25 sequencing labs in some ten different countries.

³⁴ This declaration was drafted by HUGO's Intellectual Property Rights Committee, which consisted of representatives of the public consortium and lawyers specialising in intellectual property.

³⁵ In fact four-fifths of the sequence were produced either in American public laboratories or by the Wellcome Foundation's Sanger Centre.

³⁶ '... the ethic of science, that recognizes the commonality of the ever-growing body of knowledge': *Common Thread*, p. 275.

³⁷ See von Krogh and von Hippel (eds.), *Research Policy* special issue on open source software development.

³⁸ Thus Stallman in *Free Software, Free Society*.

³⁹ *Ibid.*, p. 18.

⁴⁰ *Ibid.*, p. 21.

⁴¹ See S. O'Mahony, *Research Policy* special issue, 1179-98.

⁴² GNU is an operating system developed by Stallman and the free software movement. See *Free Software, Free Society*, pp. 31-9, 'the GNU manifesto'.

⁴³ The open source movement lays more emphasis on the financial advantages of free access to the source code; the free software movement stresses programmers' freedom to co-operate.

⁴⁴ Cf. D. Zeitlyn, 'Gift Economies in the Development of Open Source Software: Anthropological Reflexions', *Research Policy* special number, 1287-91. See also the ground-breaking article by von Hippel, 'Cooperation between Rivals: Informal Know How Trading', *Research Policy* 16 (1987), 291-302.

⁴⁵ See R. Kohler, *Lords of the Fly* (Chicago: University of Chicago Press, 1994).

⁴⁶ R. K. Merton, 'The Normative Structure of Science' (1942), repr. in R. K. Merton and N. W. Storer, *The Sociology of Science: Theoretical and Empirical Investigations* (Chicago: University of Chicago Press, 1993).

⁴⁷ D. Cohen, *Les gènes de l'espoir* (Paris: R. Laffont, 1992).

⁴⁸ See P. Rabinow, *French DNA* (Chicago: University of Chicago Press, 1999).

⁴⁹ Human Genome Organization.

⁵⁰ *Perspectives*, p. 225.

⁵¹ Von Krogh and von Hippel in *Research Policy* special number. [*Wording corrected – trans.*]

⁵² The number of developers contributing to a project can be anything between single figures and several thousand, and the number of users anything between single figures and several million.

⁵³ E.g. the open source consortia under the aegis of the French Institut National de la Recherche en Informatique et Automatique.

⁵⁴ Thus O'Mahony in *Research Policy* special number, 1179-98.

⁵⁵ See M. Cassier, 'Private Property, Collective Property, and Public Property in the Age of Genomics', *International Social Science Journal* 171 (March 2002), 83-98.