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RESEARCH ARTICLE

Exploring Philosophical Issues in the Patenting of Scientific and Technological Inventions

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Abstract Thus far, the philosophical study of patenting has primarily focused on sociopolitical, legal, and ethical issues, such as the moral justifiability of patenting living organisms or the nature of (intellectual) property. In addition, however, the theory and practice of patenting entails many important problems that can be fruitfully studied from the perspective of the philosophy of science and technology. The principal aim of this article is to substantiate the latter claim. For this purpose, I first provide a concise review of the main features of the theory and practice of the patenting of scientific and technological inventions. Second, I discuss several philosophical issues implied by these features and explore the possible contributions of the philosophy of science and technology to the clarification, or resolution, of these issues. The seven features discussed are: patents as commercial monopolies on scientific and technological inventions, the contrast between natural and non-natural subject matter, the distinction between inventions and discoveries, the reproducibility of inventions, the question of the sameness of two inventions, the distinction between the invented and the protected object, and the contrast between material objects versus concepts and theories. The article concludes with some observations on the problems and prospects of the philosophical study of the theory and practice of patenting scientific and technological inventions.

Keywords Philosophy of science and technology · Theory and practice of patenting · Scientific and technological inventions

1 Introduction

The theory and practice of patenting is a subject that is, or should be, of great interest to the philosophy of technology. After all, the granting of patents pertains to inventions, which are usually interpreted as being technological by nature. Therefore, patent application has been a regular feature of engineering and engineering sciences.

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In addition, the past decades have seen a growing commodification of academic science, a process with a major impact on the research, teaching, administration, and academic culture at general universities (Radder 2010a). A significant aspect of this commodification is the patenting of research results, in particular in the fields of computer science, physical science, and biomedical science. Over the past decades, a strong increase of academic patenting has occurred: in US universities since the 1980s and in European universities since the 1990s. Patenting and licensing have become an established feature of the work of scientists in publicly funded universities. Currently, many researchers and their administrators see the acquisition of patents and the selling of licenses as a legitimate academic aim and achievement, comparable to the publishing of articles or books. For these reasons, patenting is not only an important issue for philosophers of technology but also for philosophers of science, a point reflected in the title and the substance of this article. More generally, technology has played, and increasingly plays, a significant role in the development of the sciences, while the same applies to the role of the sciences in technology (see Radder 2009). This means that there is a subject matter for, and therefore a need of, an integrated philosophy of science and technology, which includes the study of patenting practices as one of its topics.[1]

The aim of this article is to explore several central issues implied by the theory and practice of patenting, from the perspective of the philosophy of science and technology. That is to say, the ontological, epistemological and methodological aspects of the relevant scientific or technological inventions will be explicitly taken into account. Patenting is definitely an under-researched topic, certainly within the philosophy of science but also (be it to a lesser extent) within the philosophy of technology.[2] Therefore, apart from some cases where I think that more robust conclusions can be drawn, my discussion will be exploratory and open-ended. Furthermore, since I intend to provide an overview of the significant issues, my analysis of each separate issue will have to be concise. Yet, I hope to demonstrate that the subject of patenting constitutes an intellectually exciting and a socially important topic for philosophers of science and technology.[3]

Thus far, philosophical studies of patenting have been written primarily from the perspectives of moral, social, or legal philosophy. The most general question concerns the moral, social, and legal legitimacy of the patent system as such; some possible answers to that question are briefly discussed in Sterckx (2000b, pp. 6–15) and, in the context of the broader justification of intellectual property in general, in Drahos (1996, chaps. 2 and 9). More specific studies include the analysis of the social disadvantages of the globalisation of the intellectual property laws and regulations for developing countries by David Lea (2008); the contributions to the edited volume by Sigrid Sterckx (2000a), which address the moral dimensions of patenting practices in biotechnology; and the study by David Koepsell (2000), which focuses on the legal

[1] Since patents are granted for inventions, the term "scientific invention" pertains to those technological products and processes that are brought about in contexts that are usually designated as being "scientific".
[2] For instance, a search for "patent" in the 99 articles of this journal available in April 2013 results in three hits, but none of these includes a substantial discussion of patenting.
[3] For a parallel program from a history of science perspective, see MacLeod and Radick (2013). These authors argue for a sustained study of the role of intellectual property practices (broadly conceived but including patenting) in the historical development of the sciences.

aspects of intellectual property claims concerning objects in cyberspace. These studies have produced insightful results. In contrast, to date, there are still few studies from a philosophy of science and technology point of view. This is unfortunate for several reasons. Firstly, patenting is a topical issue with far-reaching implications for the relations between current science, technology, and society. In-depth philosophical study of the scientific and technological aspects of patenting may provide significant contributions, both to the theory and practice of patenting itself and to the more general moral, social, or legal debates concerning science and technology policy. Thus, the point of this article is not to study scientific and technological issues *instead of* moral, social, or legal questions. Rather, as we will see, a philosophy of science and technology perspective may highlight novel moral, social, or legal issues or shed a new light on established issues. Hence, seriously addressing this topic offers the philosophy of science and technology the opportunity to increase its social relevance. Secondly, a study of the subject of patenting from the perspective of philosophy of science and technology is not only socially relevant but also intellectually rewarding. As I hope to show in this article, the theory and practice of patenting includes a variety of intellectually challenging subjects to which philosophers of science and technology could make substantial contributions.

To stave off potential confusion, it is *crucial* to be aware of the differences between a legal and a philosophical approach. Legal scholars and practitioners often stick to the literal terminology that is employed in patent laws, regulations, and lawsuits. In contrast, I will primarily address such issues from a conceptual perspective. There are, for instance, differences between the USA and the countries that participate in the European Patent Organisation. However, if US and European laws and regulations make use of distinct terms that are conceptually connected, I will focus on these mutual connections rather than on the terminological differences. Examples are the notions of discovery and non-naturalness that will be introduced and discussed in Sections 2 and 3. More generally, a philosophical approach aims to provide its own interpretations and draw its own conclusions concerning both the theory and the actual practices of patenting. In doing so, this approach includes interpretations and conclusions that are implicit in, or can be plausibly inferred from, the legal theories, terminology, and practices.

The plan of the paper is as follows. First, Section 2 starts with a brief summary of the main requirements and criteria for patentability; next, it presents a list of seven central features of the theory and practice of patenting that can be fruitfully analyzed from a philosophy of science and technology perspective. In Section 3, which constitutes the core of this article, I offer a sketch of such analyses and I briefly explain the philosophical issues implied by these features. I conclude the article with some observations on the problems and prospects of the philosophical study of the patenting of scientific and technological inventions.

2 Central Features of the Theory and Practice of Patenting

A patent is a legally granted, commercial monopoly based on an invention that needs to meet the criteria of being novel, non-obvious, and useful. The underlying assumption (which has been both endorsed and questioned by economists) is that patented inventions will, as a rule, stimulate the development of socially useful, or at least commercially successful, innovations. Before the criteria for patentability can be applied, however, the invention should be shown to be eligible for patentability on the basis of several further requirements, which seem to be implied by or derived from the notion of an invention. These requirements for patentability include the following: patentable subject matter is required to be non-natural; the patentable result must be a "human-made" invention and not a discovery of "freely occurring phenomena"; the invention should be reproducible by the skilled peers of the applicant; and the patentable inventions need to be material, implying that they should not be conceptual or theoretical.

It will be clear that these requirements and criteria are related in several ways. These relations will come up at some points in the subsequent discussion, but a systematic analysis transcends the scope of this article. Furthermore, the stated requirements and criteria are the ones endorsed by the official patenting doctrines. As the many shocking examples provided by Seth Shulman (1999) demonstrate, the real world does not always conform to these official doctrines, to put it mildly.

From the above description, we can extract seven central features of the theory and practice of patenting. In this section, these features will be introduced and described in a preliminary way. In the next section, they will be explained in more detail, with a view to their philosophical presuppositions and implications.

(a) A patent is a legally granted, *commercial monopoly* to exploit *a type* of technological invention. That is to say, the patent holder has the exclusive right to make financial profit by producing and selling any tokens of the type of the invention or by licensing others to do so. This right is limited to a period of 20 years. It is not an absolute right, however, since the processes of making and selling the invention will be subject to the ordinary laws of the states in which the invention is commercially implemented.

(b) Patentable subject matter—that is, subject matter that can be patented if the invention satisfies all further criteria—is required to be *non-natural*. That is to say, a certain product or process is not eligible for patentability if it is purely natural, in the sense that it does not include any significant productive contribution by the inventor.

(c) The patentable subject matter must be a *human-made invention*. According to US patent law and terminology, discoveries can be patented as well. However, in this context, the expression "discovery" refers to "human-made" products and processes, and thus it effectively excludes discoveries of "freely occurring phenomena". Since philosophers typically refer to this kind of phenomena when using the term "discovery", I will stick to this philosophical usage. Hence, discoveries, taken in this philosophical sense, cannot be patented.

(d) To qualify as a genuine invention, the submitted invention should be *reproducible* by the skilled peers of the applicant. After all, a major social goal of granting a patent is to promote the dissemination of the invention through including further tokens of it in commercially successful innovations. For this purpose, one needs to be sure that new tokens of the original invention *can* in fact be realized, and hence the original invention should be reproducible by all those who are "skilled in the (relevant) art".

(e) In actual practice, conflicts may, and do, arise concerning the question of whether the legal monopoly on a particular invention has been violated by a second party. Infringement of a patent will take place if the invention exploited by the second party is "the same as", that is, *identical* or at least *significantly similar* to, the original invention. However, a compelling legal demonstration that two inventions are really the same, and hence that the second party has in fact infringed the original patent, is often a complicated matter that may require a prolonged and costly lawsuit.
(f) In actual practice, patent *protection* is not limited to the exploitation of the invention itself, but often extended through *further claims* "based on" the invention. The underlying idea seems to be that it is reasonable to assume that the particular invention itself immediately implies, or may easily lead to, further useful results that would not have been possible without it. Patents whose claims go far beyond the particulars of the original invention are called broad patents.
(g) Patentable inventions need to be *material*. Here, materiality does not necessarily mean that the invented product or process should be literally "tangible" but rather that they are physical, in the modern, scientific sense of that term in which radio waves, for instance, are physical things. An important implication is that *conceptual or theoretical* inventions cannot be patented. Only the material realizations of ideas (for instance, through a technological device, a chemical composition of matter, or a biological test procedure) are patentable. The ideas, concepts, or theories that underlie such realizations are explicitly excluded from patentability.

3 Philosophical Implications and their Consequences

Let us now take a closer look at the seven features of patenting briefly described thus far. I hope to show that these features entail certain problems that require a deeper philosophical analysis and assessment. I will first repeat the description of the relevant feature given in the previous section and then explain the implied philosophical problems and their possible legal, social, or moral consequences.

(a) A patent is a legally granted, *commercial monopoly* to exploit *a type* of technological invention.

(*a1*) Together with copyrights, trademarks, and trade secrets, acquired patents are often designated as "intellectual property".[4] Several recent philosophical studies of patenting have focused on the notion of property that is implied in this designation (see, e.g., Biron 2010; Wilson 2010). The problem is that the reference to a *type* of invention significantly complicates the applicability of the usual notion of property.[5] Since ordinary property always pertains to one or

[4] For an in-depth discussion of the philosophical issues surrounding intellectual property, see Drahos (1996).
[5] In contrast, the so-called material transfer agreements, which may be part of licensing arrangements, do involve the exchange of tangible research materials, that is, tokens of the invention, such as particular chemical compounds or biological cell cultures.

more tokens of a certain item, the philosophical commentators are puzzled by what could be meant by “owning a type of thing”.

However, whatever the solution of this puzzle may be, its significance will be primarily academic or rhetorical. The reason is that, in the context of patenting law and patenting practice, nothing hinges on a precise definition of the notion of property. After all, the primary idea of “a commercial monopoly to exploit the invention” accurately captures the meaning of “a patent”. In a conceptual sense, the notion of property is redundant. Hence, it would be better to speak of an “exclusive, though conditional, right”, a right that is based on making available a socially useful achievement rather than a right that derives from a specific (intellectual) property. Yet, connecting the notions of patent and ownership may be, and has been, influential as a rhetorical device. Thus, claims that patenting (parts of) living organisms implies the ownership of life by private commercial parties have been used repeatedly in criticisms of the expansion of European patent regulations to biotechnological inventions (see Sterckx 2000a). In spite of this, the more reasonable interpretation is that what patentees own are the patents, and not the organisms.

There is a further reason for de-emphasizing the notion of intellectual property in the context of patenting. As Henk van den Belt (2010) has shown in detail, from a historical perspective, this notion has undergone a radical transformation: from a recognition and reward for scientific or technological accomplishments granted by peers (for instance, expressed in such phrases as “Einstein’s theory of relativity” or “Edison’s light bulb”) to a legally acquired commercial monopoly. Separating the notion of intellectual property from the context of patenting would make room for reclaiming its original, noncommercial usage.

To avoid misunderstanding, let me add that, although the patent monopoly pertains to a type of invention and does not entail the ownership of this type, the acquired property rights of specific tokens of an invention may constitute a substantial, rather than a merely academic or rhetorical, issue. This is, for instance, the case when the invented tokens consist of, or include, genes, tissue, organs, or other body parts of a particular person. To see the significance of this issue, consider the case in which a commercial company has *privately* appropriated the relevant body parts of a person who has donated them for the purpose of supporting the *public* interest through advancing scientific research (for further discussion of such issues, see Parry and Gere 2006).

(*a2*) In addition to the issues discussed so far, there is another problem with the idea of granting intellectual property in science and technology, especially in recent, “big” science and technology. The notion of intellectual property, including patents, is often interpreted in analogy to the natural rights interpretation of ordinary property: a particular person has a natural property right in some item in as far as the availability of this item is the direct and unambiguous result of his or her own labor.[6] Similarly, on this interpretation, patents on inventions are rightfully granted to particular inventors or to a particular group of inventors because they have made the invention available. This presupposes that such inventions, or at least their essential characteristics, can be justifiably attributed to particular people or groups. That is to say, the

[6] For a differentiated discussion of John Locke’s influential natural rights interpretation of ordinary property and its implications for intellectual property, see Drahos (1996, chap. 3).

patent system is based on a specific theory of (scientific or technological) invention, a theory that assumes that, as a rule, it is possible to ascertain who, or which group, has really made the invention or has at least made the decisive contribution. Therefore, an important question concerns the plausibility of this theory of invention.

A highly relevant fact regarding this question is that the current scholarly literature in the history and philosophy of science and technology tends to reject the attribution of inventions to clearly specifiable people or groups. For instance, in an illuminating study, Reijo Miettinen discusses four theories of invention and evaluates them on the basis of an extensive case study of the invention of enzyme-aided pulp bleaching. This invention exploited research results published in 1986 and was implemented in the early 1990s, among other things in the paper recycling industry. Miettinen criticizes individualistic accounts of this particular invention and convincingly demonstrates the significance of the collective processes of preceding cultural maturation (of the context that supplied the crucial resources that enabled the invention) and later social attribution (due to a series of unanticipated events in the early 1990s). He concludes that "enzymatic pulp bleaching was a collective, distributed invention", and he presumes that "a careful empirical analysis would often uncover this kind of social and shared nature of the early phases of the innovation process" (Miettinen 1996, p. 44). Furthermore, in addition to inventions facilitated by the collective achievements of earlier scientists and technologists, it is often the case that the same inventions are made more or less simultaneously by independent inventors or groups of inventors. In a recent article (significantly entitled "The myth of the sole inventor"), Mark Lemley (2012, pp. 711–735) has provided a detailed review of the extensive literature on this phenomenon. He concludes that

> surveys of hundreds of significant new technologies show that almost all of them are invented simultaneously or nearly simultaneously by two or more teams working independently of each other. Invention appears in significant part to be a social, not an individual, phenomenon. (Lemley 2012, p. 711)

Of course, all of this is not to deny that specific individuals contribute to the making of inventions. The point is rather that there is no objective and quantitative method that can be used to establish that their contribution is larger or more decisive than what is contributed by the other independent inventors or by the collective of other scientists and technologists.[7]

(*a3*) As mentioned in the introductory section, patenting and licensing is also increasingly practiced in academic institutions (Slaughter and Rhoades 2004, chaps. 3 and 4; Nowotny 2005, pp. 20–25; Sterckx 2010, pp. 45–46). In so far as these institutions are publicly funded (or are privately funded nonprofit institutions), it is questionable whether acquiring commercial monopolies is compatible with their explicit or implicit missions. As a matter of fact, many public and nonprofit universities explicitly claim to adhere to some variety of a Mertonian ethos.[8] Elsewhere I

[7] See also Parry and Gere (2006, pp. 154–157), who reach the same conclusion for the analogous case of the production of biological artefacts. It is remarkable, though, that these authors do not extend their conclusion (and their advocacy of a "collective custodianship" model) to the case of patenting scientific inventions, which similarly involves a privatized appropriation of collective achievements.

[8] In Robert K. Merton's own phrasing, the core values of such an ethos are universalism, communism, disinterestedness and organized skepticism (Merton 1973/1942).

have shown, first, that the existence and significance of what I call a "deflationary, neo-Mertonian ethos" can be vindicated against historical, sociological, and philosophical objections; and, second, that acquiring commercial monopolies, such as patents, is incompatible with this ethos of science (Radder 2010b). Thus, these universities should either abolish their patenting practices or denounce their adherence to the Mertonian ethical codes. If they do neither—which is unfortunately the case thus far—their ethos proves to be no more than a superficial ideology that masks their real behavior.

(b) Patentable subject matter is required to be *non-natural*. In the USA, if a (human-made) product or process has a natural counterpart, it is patentable only if it is "markedly different" from this counterpart. For instance, even if the chemical components of a certain dye are seen as natural matter, the dye can be patented if its composition is markedly different from any naturally occurring substance. Under the European Patent Convention, patentable subject matter needs to be a "technical solution to a technical problem". Here, "technical" is clearly used in the sense of "technological", and not in the sense of "specialized", as the latter is taken into account by the additional criterion that the invention should constitute a genuine inventive step. It is therefore plausible to conclude that according to both the European and the US law, the basic aspect of a non-natural product or process is that it is, either wholly or substantially, artifactual (or human-made) and in this sense different from human-independent products or processes.[9] Yet, this should not be taken to imply that the two interpretations of the notion of non-naturalness are fully identical. The main difference seems to be that the US approach focuses on the character of the invented product, while the European approach concentrates on the nature of the process of invention.

(*b1*) It will probably not be surprising that these requirements of non-naturalness entail several philosophical and legal problems.[10] No wonder that substantial controversy concerning this aspect of specific patent applications may, and does, arise. For instance, thus far, numerous product patents on genes and (parts of) organisms have been granted. In vivo, these entities are usually seen as natural. But do these products become artifactual and markedly different from their natural counterparts simply by "isolating" or "purifying" them in the laboratory?[11] If so, chemically pure water (of which one may plausibly assume that it does not occur in nature—see Weisberg 2006, pp. 339–341) would also be non-natural. Is this acceptable? In 2010, a US Federal District Court decided that, in the case of two human genes involved in contracting breast cancer, isolating or purifying these natural objects is not enough to make them markedly different human-made artifacts (Schwartz and Pollack 2010). Although this was a remarkable decision, it is certainly not the end of the dispute concerning this

[9] See also Hanson (2007, p. 524), who argues that, in contrast to the natural sciences, the objects of the technological sciences are human-made objects.

[10] For illuminating, though diverging, accounts of the concepts of naturalness and non-naturalness, see Lee (1999), Luper (1999), and Siipi (2008). An important issue is whether naturalness is taken to be an all-or-nothing affair (each entity is either natural or non-natural) or a matter of degree (a particular entity may be more natural, or less natural, than another one).

[11] Additional ontological questions relating to the patenting of genes, in particular concerning the notions of function and information, are discussed in Calvert (2007).

controversial issue. In the course of 2013, a final decision is expected to be taken by the US Supreme Court (Kevles 2013).

It seems to me that such issues could be simplified, at least conceptually. Assume, for the sake of argument, that having a patent system is a good thing. In this case, one might consider to abandon the US interpretation of the notion of non-naturalness and generally adopt the European idea that an invention is non-natural if it constitutes a (substantial) technical solution to a technical problem. After all, this focus on the technological nature of the inventive *process* adequately captures the rationale underlying the granting of patents. Under these conditions, I think that nothing will be lost by simply dropping any reference to "the products of nature" and their "markedly different", non-natural counterparts. In this way, the issue would be conceptually reduced to the more focused question of whether an invention (e.g., of chemically pure water or of the mentioned breast cancer genes) really constitutes a novel and substantial "inventive step".

(*b2*) In the case of patenting the results of scientific research, the contrast between the natural and the non-natural and its specification through the mentioned US and European requirements seems to require a realist ontology. That is, it presupposes an ontological distinction between a human-independent nature and a human-dependent domain of markedly different technological products and processes. However, proponents of a social-constructivist ontology can be expected to question the appropriateness of this distinction. Steve Woolgar, for instance, claims that

> the existence and character of a discovered object is a different animal according to the constituency of different social networks. … The argument is not just that social networks mediate between the object and observational work done by participants. Rather, the social network constitutes the object (or lack of it). (Woolgar 1988, p. 65)

Thus, advocates of a social-constructivist ontology deny that assuming the existence of a human-independent nature makes sense. Moreover, in their case studies of scientific practices, the constitutive "work" is shown to include the uses of technological resources and equipment. Therefore, if they are consistent, ontological constructivists have to declare that not only invented things but anything whatsoever (for instance, a particular star) meets the non-naturalness requirement for patentability. Whether these antirealist academics will be able to enforce their views in actual patenting practices is, of course, another matter.

(c) The patentable result must be a "human-made" *invention*, and *not a discovery* of "freely occurring phenomena". Although this requirement is obviously closely related to the previous one, its focus is on epistemological and methodological questions rather than on the primarily ontological issues discussed under (b).

(*c1*) Through the qualification "freely", this requirement presupposes that the relevant discoveries do not have a (substantial) "human-made" dimension. Hence, it seems to require a realist epistemology. An illustration is provided by Michael Polanyi, who states that

> the [patent] law endorses … a sharp distinction between the knowledge of the facts of nature (achieved by discovery) and the knowledge of an operational principle (achieved by invention). (Polanyi 1962, p. 177)

Yet, although this statement will surely apply to many claims made in the context of patent laws and regulations, this realist epistemology does not, or at least should not, have direct implications for patent practices. The reason is that knowledge, in contrast to its use for commercial purposes, cannot be patented. What is more, one of the main aims of the patent system is to guarantee the public availability of the knowledge used or acquired in the inventive process. After all, the inventor is required to disclose this knowledge by means of a description that is to be submitted to the relevant patent office. Even if the practical adequacy of such descriptions may be questioned (see point (*d1*) below), the principled distinction between the knowledge and its commercial use remains a basic feature of the patent system.

(*c2*) A related issue is that the distinction between invention and discovery also presupposes a strong divide between science and technology. In the recent literature, however, this presupposition has been questioned on the basis of different accounts of the science-technology relationship (see Radder 2009; Van den Belt 2009). Some authors (for instance, Lelas 1993) advocate a science-as-technology view. According to this view, "science discovers because it invents" or, in a Heideggerian phrasing, "nature is at once revealed and produced", and the two sides of this process cannot be separated, as contemplative accounts of scientific discovery attempt to do. Other authors claim that, during the past decades, the scientific enterprise has been transformed into what is called the regime of technoscience (Nordmann 2011). In a similar vein, Peter Galison conjectures that

> the science of the first half of the twenty-first century will increasingly involve fabricated objects, not just as "applications" but as the primary objects of study in the traditionally designated "pure" parts of physics, chemistry, and biology. (Galison 2008, p. 117)

Clearly, such authors will also reject the presupposition of a strong divide between science and technology, at least for the recent past and the foreseeable future. Therefore, if the proponents of a technoscientific or a science-as-technology view are right, there is no reason to exclude any results of recent scientific research from patentability (if they also meet the other requirements and criteria).[12]

One can, however, also give a more pragmatic twist to this issue. In this spirit, David Resnik (2002) argues that, in many cases and especially those concerning genes, there is no objective distinction between discovery and invention. Both discoveries and inventions involve cognitive, social, and causal contributions by humans. When these contributions (in particular our causal interventions) are "primary" or "substantive", we speak of inventions; when they are "secondary" or "mere conditions", we are dealing with discoveries. Resnik's point is that particular judgments of primacy or substantiveness are not objective but essentially dependent on values and interests, which may be scientific, technological, environmental, economic, moral, political, or religious. For this reason, he concludes that the debate on

[12] Although I myself disagree with strictly technoscientific or science-as-technology views (see Radder 2011a, b, 2009, pp. 79–87), they do address significant patterns of complicated phenomena, and hence they cannot be refuted by simply stipulating a fundamental distinction between science and technology from a philosophical armchair position.

patents, especially gene patents, should not be based on a metaphysical distinction between discovery and invention. Instead, it should fully acknowledge the essential value-ladenness of this issue and aim at a fair assessment and weighing of the relevant values and interests that are brought to bear on the kinds of patents in question.

(d) To qualify as a genuine invention, the submitted invention should be *reproducible* by the skilled peers of the applicant (Bostyn 2001, p. 200). As we have seen, the applicant is required to disclose the invention by providing the relevant patent office with a written description of it. In practice, this description is often rather brief and schematic. Yet, the assumption is that, given the contemporary state of the art, the description should enable the reproduction of the invention by the skilled peers of the inventor. Moreover, this reproduction should be feasible without undue (additional) experimentation.

(*d1*) In fact, ascertaining the sufficiency of the description of an invention may be far from straightforward, in particular in legal contexts in which there are contesting parties who have opposing commercial interests. An illuminating illustration can be found in a detailed historical case study by Kathryn Steen (2001, pp. 109–118). The study reviews a controversy concerning the pecuniary value of a set of German chemical patents that were confiscated by the USA after World War I. The point is that patents are less profitable if the description of the invention is less than sufficient, since this will necessitate substantial additional research to be able to reproduce the invention. Steen concludes that

> scientists at each German firm wrote and filed the patents in such a way as to hinder rapid duplication by rivals, but the German experience suggests these barriers were surmountable by knowledgeable competitors, which the American market lacked. (Steen 2001, p. 122)

Even without opposing interests, the sufficiency of description may constitute a significant problem, for two reasons. First, if realizing an invention depends on tacit and local knowledge that is not available to the peers of the original inventor, judging its reproducibility on the basis of a (brief) explicit description will be questionable. Some authors (Polanyi 1967; Collins 2010) have provided detailed studies of the nature and role of tacit and local knowledge. However, as far as I know, such studies have not yet been applied to recent patenting practices. Second, Greg Myers (1995, pp. 92–97) argues that the problem of insufficient disclosure of the invention is reinforced by the tendency of patent agents to focus the patent description on the further, more general claims that are said to be based on the concrete invention. This is an important issue to which I will return under point (f). My conclusion concerning the present issue is that it remains to be ascertained how widespread and serious the potential lack of reproducibility is.

(*d2*) In scientific and technological practice, several types of reproducibility can be found (Radder 1996, pp. 11–26). Two of those are immediately relevant to the study of patenting. I mean the reproduction of the entire process of realizing the invention versus the mere reproduction of the result, that is, the product of this process. To distinguish the two, in the latter case I speak of "replication". In the context of patenting, the invention needs to be non-obvious, that is, a nontrivial technological achievement. For this reason, one would expect that, *also in the case of product* *patents*, the reproducibility of the invention should pertain to the repeatability of the entire process of realizing the invention. In fact, however, in applications for product patents current patenting regulations and practices also admit replication, that is, the mere reproduction of the product, as a sufficient disclosure of the invention (Van Overwalle 2000, pp. 203–204; Bostyn 2001, pp. 201). The question is whether this procedure can be justified. After all, how can one judge the non-obviousness of an invention if one does not even know whether its process of making can be repeated by others?

As I will show under (*f2*) and (*g2*), this limitation to the replicability of the product entails further theoretical problems. In addition, it has substantial practical implications, especially in the case of living organisms. Suppose the invention is a genetic modification of a certain crop, for instance rice. Suppose, furthermore, that the requirement of reproducibility would pertain to the specific process of making the modified rice and that the protection would accordingly be limited to that process. In that case, the patent would not be valid for the reproductions of the rice through ordinary farming procedures. To avoid this implication, patenting authorities have stipulated that in the cases of sexually or asexually reproducing organisms, reproducibility of the product suffices. It will be clear that this stipulation maximizes the scope of these patents to the advantage of the producers of genetically modified crops. At the same time, it has significant disadvantages for ordinary farmers, who now have to pay for the traditional practice of reusing part of the harvest of these crops as seeds for the next season (see Lea 2008).

(e) Infringement by a second party presupposes that the invention exploited by this party is the same as, that is, either *identical* or *significantly similar* to, the original invention.

(*e1*) In practice, the original and the (alleged) copy will usually not be *strictly* identical. In the case of complex scientific or technological inventions, this will probably never be true. In these cases, the question is how similar the original and the contested invention need to be in order to count as "the same". Controversies will arise if the contending parties have opposite views concerning the question of what constitutes the "identity" of the patented invention. In legal cases, social and economic power may be the decisive factor in resolving such controversies (for examples, see Van den Belt 1989; Mackenzie et al. 1990). A relatively recent phenomenon is that big multinational companies (such as Microsoft, Apple, and Google) use their patents not for developing the invention into an actual innovation but rather as offensive and defensive weapons in legal struggles with their competitors (Keuning 2011). Such practices raise obvious and important questions, the crucial one being: are these practices socially and morally legitimate from the perspective of the basic purposes of our patent system?

(*e2*) From a philosophical perspective, the issue can be fruitfully studied as a specific illustration of the general "problem of the next case". This problem arises if we need to answer the question of whether a previous and a next case, which exhibit both similarities and differences, should, or should not, count as "the same". On the basis of their finitist theory of meaning, Barnes et al. (1996) argue that any resolution of this problem is irreducibly social and cannot be based on allegedly intrinsic features of the invention and its contested copy. Other philosophers, however, might disagree and propose alternative theories of meaning and identity (for some discussion, see Radder 2006, chap. 15). The challenge, then, is to demonstrate the applicability and fruitfulness of theories of meaning and identity to the issue of the sameness of the original and the contested technological invention.

(f) In actual practice, patent *protection* is not limited to the exploitation of the invention itself, but often extended through *further claims* "based on" the invention. The protection a patent provides is phrased in terms of a number of claims. The idea is that these claims describe the content of the invention and state what is implied by it or can be immediately inferred from it. If the claims stay close to what has been actually invented, the patent has a narrow *scope of protection*. In actual practice, however, the implications of, and the inferences from, the inventions are often interpreted quite broadly. In the case of such broad patents, the scope of protection is not limited to the exploitation of the invention in a strict sense, but goes substantially beyond what has been actually made available (see Sterckx 2000b, pp. 21–25; Bostyn 2001, pp. 42–53). In fact, the broader claims are frequently seen to be the primary ones, with the original embodiment being "just an illustration". In an illuminating account of the writing of two patent applications, Greg Myers contrasts the description of patents with the usual format of scientific articles.

> A scientific article starts with the specific case and then argues for broader implications in the conclusion. … A patent, on the other hand, starts with the broadest form, and then presents the actual work done as a specific embodiment of it. (Myers 1995, p. 92)

(*f1*) In discussing issues in the theory and practice of patenting, it is crucial to acknowledge the distinction between the "invented" and the "protected" object(s). Lack of acknowledging this distinction may result in serious confusion. An illustration is the analysis of the nature of the "objects of intellectual property" by Laura Biron (2010, pp. 383–385). As a central part of her argument, she constructs a dilemma by concluding that the objects of intellectual property should be both abstract entities and concretely created things. However, this "dilemma" can be easily resolved (at least in the case of patents) by realizing that it is the protected objects that are abstracted types, while the invented objects are concrete creations. Put differently, a natural construal, and resolution, of the "dilemma" is the following. Since patenting a token of an invention makes no sense, patent protection necessarily pertains to a type. Yet, this protection is, or should be, justified on the basis of an invented token.[13]

(*f2*) Frequently, patent applicants provide hardly any evidence for the extension of their patent protection by adding further claims allegedly based on the original invention. A well-known example of an overly broad patent is the US oncomouse patent granted to Harvard University in 1988. Although the actual research was limited to a specific kind of mice, the applicant applied for, and was granted, a patent on the exploitation of the invention "for all transgenic, nonhuman, mammalian animals" (Sterckx 2000b, pp. 23–25). Another telling illustration is the European

[13] By focusing on the property dimension of intellectual property, Drahos (1996) overemphasizes the significance of the abstract, protected objects at the expense of the concretely invented objects.

patent on soybeans acquired in 1994 by the biotechnology firm Agracetus. Based on a specific, single modification of a soybean cell, this patent covered all genetically manipulated soybeans, by the method used in the invention *and* by any other possible method.[14] Finally, on the basis of a detailed examination of 1,167 claims from 74 patents on human genetic material, Paradise et al. (2005, p. 1566) conclude that "many patents claimed far more than what the inventor actually discovered".

Furthermore, in assessing broad patent applications, the burden of proof is often reversed (Bostyn 2001, pp. 177–178). Instead of demanding positive evidence for the extension of the monopoly, the patent examiners merely require that there is no evidence for non-extension. Thus, patent applicants frequently aim at maximizing the gap between the actual invention and the patent protection, that is, between the invented and the protected object. If we call the conjunction of all patent claims hypothesis *H*, the applying researchers do put forward, in a Popperian sense, a risky conjecture. The purpose of this is, however, the gain of maximum profits through legal protection against potential infringements, rather than the falsification (or corroboration) of *H* through severe testing procedures. From a scientific point of view, wildly extending one's claims on the basis of minimal evidence and without the intention of providing further evidence is at best sub-optimal and at worst bad science (see Radder 2004, pp. 282–286).

(*f3*) This point can also be phrased in a manner that relates it directly to recent insights concerning the relationship between science and technology. In fact, the broader claims often constitute a diversity of "possible technological applications" of a scientific invention. Granting an exclusive reward to the scientific inventor presupposes that these possible technological applications can be realized relatively easily on the basis of the invention. That is to say, the invention is claimed to be the decisive contribution, while the "applications" are seen to be no more than its straightforward uses. Thus, this aspect of the patent system seems to be based on the model of technology as "applied science", at least on those versions of this model that assume that technologies are more or less straightforward and unproblematic applications of scientific achievements. This assumption, however, has been severely criticized in historical and philosophical accounts of the relationship between science and technology (see, among many others, Layton 1974; Boon 2006). By criticizing the lapse from scientifically possible applications to full-fledged technological innovations, this literature also questions, be it implicitly, a significant feature of the modern patent system.

(g) Patentable inventions need to be *material*; *ideas* and *conceptual or theoretical inventions are not patentable.*[15]

(*g1*) Understanding and applying this condition requires some account of what it is to be conceptual or theoretical and how concepts and theories relate to material things. Current patenting practice does not readily provide for this. Therefore, by

[14] See Shulman (1999, pp. 91–98). In response to opposition, in 2007 this European patent, then owned by Monsanto, was revoked for lack of novelty (thus, remarkably enough, *not* for its overly broad character; see http://www.nature.com/news/2007/070504/full/news070430-14.html#comments).

[15] For this reason, Wofgang Balzer's inaccurate usage of such phrases as the patenting of "scientific knowledge" and "non-material ideas and propositions" (Balzer 2003, p. 91 and pp. 97–98) detracts from the valuable parts of his criticism of academic patenting.

developing a plausible account of these notions, philosophers of science and technology could make a significant contribution to the clarification of this issue. By way of example, consider physicalism, which claims that concepts and theories are, ultimately, material or physical brain states. Paul Churchland, for instance, defines concepts and theories as "specific configurations of synaptic connections in the brain" (Churchland 1992, p. 354), and hence denies them a non-material ontological status. Thus, from the perspective of physicalism excluding concepts and theories from patentability cannot be justified. However, Churchland's account, and more generally physicalist accounts, of concepts and theories have been severely and, I think, convincingly criticized (see, e.g., Kirschenmann 1996; Radder 2001). Therefore, the problem of providing a plausible explication of the distinct ontological status of concepts and theories, and of demonstrating its relevance to the patenting issue, remains.

However, even if we have a plausible account of conceptuality and theoreticity, there may be further questions concerning specific applications of this account. In this respect, software constitutes an important challenge: is software conceptual or material? Although much software is nowadays routinely patented, this fundamental question has not been convincingly answered. Is software primarily akin to a (not patentable) general mathematical formula or is it primarily a (patentable) part of a specific machine? Or is the established legal ontology not applicable to software, since it seems to possess both a conceptual and a material dimension? Similar basic questions pertain to other computer-mediated phenomena (so-called "objects in cyberspace"; see Koepsell 2000).

(*g2*) A large class of patents, the product patents, provide protection for the product *as produced through any possible process*. An example is the Agracetus soybean patent mentioned under the previous point (*f2*). In cases like this, the disclosure of the invention can, by definition, never be sufficient. What is more, the essential *abstraction* from any specific process entails that the protected object is, effectively, a conceptual entity. Hence, product patents grant a monopoly on a concept (or an idea) rather than on a particular type of material entity produced by means of a specific process.[16] If this analysis is correct, it implies that the numerous product patents that have been approved thus far are in fact illegal since concepts are excluded from patentability.

In this respect, process patents (that is, patents that provide protection on a specific process through which a product can be produced) are clearly different. To be sure, as we have seen under point (*f1*), the protected object is always a type of thing and as such it includes an extrapolation to future possibilities. In the case of process patents, however, these possibilities have been specified, since they pertain to the technological reproducibility of a particular process of invention. In contrast, in the case of product patents, the extrapolation concerns the claimed replicability of the relevant product, independently of any specific process. In sum, while reproducibility claims of specific processes can be interpreted as technological by nature, replicability claims are basically conceptual or theoretical (Radder 2006, pp. 146–149).

[16] For the details of this argument, see Radder (2006, chaps. 9, 10 and 16).

4 Concluding Remarks

At present, most of the issues explored in the previous section constitute an open-ended research program for philosophers of science and technology. Some may turn out to be more interesting and fundamental than others. I myself have studied some of these issues in detail (in particular, (*a3*), (*c2*), (*f2*), and (*g2*)), and found that substantial philosophical research may be done on at least this part of the program.

What will have become clear from the analyses of the seven central features of the theory and practice of patenting in the previous section, is that philosophers of science and technology do not always agree on the relevant philosophical approaches and claims. Because of the fundamental nature of the issues at stake and the de facto diversity of views, universal agreement on all issues among all philosophers will not be forthcoming. In this respect, philosophical views of patenting cannot be assumed to be fundamentally different from other basic views in the philosophy of science and technology.

In view of this fact, what further results may be expected if philosophers of science and technology will start a serious and sustained study of patenting? I think that the results will be differentiated (cf. Radder 1996, pp. 183–187). On some points, we may expect to achieve a reasonably large consensus. As I see it at this moment, these points include the limited relevance of the notion of property, the contradiction between academic patenting and the accepted ethical codes of appropriate scientific conduct, and the crucial significance of the distinction between the invented and the protected object. On other points, we may achieve a substantial clarification of the relevant issues. In this way, philosophical work might lead to an informed reconsideration and a better assessment of the range of justified patenting. These points include the problems the increasingly collective character of scientific and technological invention poses for a system based on the rewarding of individuals, the explication of the notions of (non)-naturalness, discovery and invention, the relevance of the different types of reproducibility, and the legitimacy of product patents. On still other points, however, philosophers can be expected to remain as divided as the other social actors involved in the patenting practices and the social debates on their legitimacy. In many cases, these points will be related to fundamental, value-laden disagreements concerning the private appropriation versus the public interest of the results of scientific and technological research. Such points of fundamental contention will probably include the issues of what constitutes infringement and the legitimacy of broad scope protection.

This leads me to a final, and even more wide-ranging, point. Quite a few of the issues discussed in the previous section show that there may be significant clashes between the common sense or policy-driven philosophies underlying patent law and regulations, on the one hand, and certain general, academic theories of science and technology, on the other. An intriguing and difficult question concerns the consequences of this fact. Does it imply that the academic philosophies are somehow wrong or does it mean that the common-sense and policy-driven philosophies are untenable? In the latter case, the application of the relevant academic philosophies would entail the necessity of substantial changes in patent law and patenting practices. An important further set of questions, then, is how such changes could be implemented and what role philosophers of science and technology might play in advancing this process. As the discussion in the preceding paragraph suggests, such changes might be in part facilitated through research in philosophy and the social or human sciences. In part, they will also depend on potential shifts in the balance of social power relations, in particular those concerning the relation between private and public interests.

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