UNIVERSITY OF SURREY

Faculty of Arts and Social Sciences
Guildford, Surrey GU2 7XH UK

Professor Ryan Abbott, MD, JD, MTOM
Professor of Law & Health Sciences

School of Law

T: +44 (0)1483 682851
E: r.abbott@surrey.ac.uk

www.surrey.ac.uk/law/people/ryan_abbott

November 5, 2019

Director of the U.S. Patent and Trademark Office
P.O. Box 1450
Alexandria VA 22313

RE: **REQUEST FOR COMMENTS ON PATENTING ARTIFICIAL INTELLIGENCE INVENTIONS**

To the United States Patent and Trademark Office:

My name is Ryan Abbott, I am Professor and Chair of Law and Health Sciences at the University of Surrey in the United Kingdom, and Adjunct Assistant Professor of Medicine at the David Geffen School of Medicine at UCLA. I am a registered Patent Attorney with the USPTO.

I would like to thank the USPTO and Director Iancu for their interest in this subject and for this opportunity to comment on patenting AI inventions.

While the broader topic of "AI inventions" raises a myriad of important issues, I will restrict my comments to "AI-generated inventions" which I will define as a "patentable invention generated by an AI in circumstances such that the AI, if a natural person, would be a patent inventor." I will not address issues such as whether AI or software should be patentable, the appropriate scope of protections for "computer-implemented inventions", database protections, or even patent infringement "by" AI.

I have also attached a few academic works I have written on the subject of AI-generated inventions, also available for download on SSRN (http://ssrn.com/author=1702576), that address some of the questions in significantly greater detail:

1. Ryan Abbott, *Everything is Obvious*, 66 UCLA. L. REV. 2 (2019) (Abbott, 2019a)

2. Ryan Abbott, *Artificial Intelligence, Big Data and Intellectual Property: Protecting Computer-Generated Works in the United Kingdom, In* RESEARCH HANDBOOK ON INTELLECTUAL PROPERTY AND DIGITAL TECHNOLOGIES (Tanya Aplin ed., Forthcoming 2019) (Abbott 2019b)

3. Ryan Abbott, *I Think, Therefore I Invent: Creative Computers and the Future of Patent Law*, 57 B.C. L. REV. 1079 (2016) (Abbott, 2016)

I encourage the USPTO to take note of the substantial academic scholarship that exists with respect to AI-generated inventions, some of which dates back to at least the 1960s. A partial list of such scholarship is available at http://artificialinventor.com/resources/. This website primarily describes efforts by an international group of patent attorneys, including myself, to obtain patents for AI-generated inventions in the U.S. and internationally. It also serves as a general resource on AI-generated inventions.

1. Inventions that utilize AI, as well as inventions that are developed by AI, have commonly been referred to as "AI inventions." What are elements of an AI invention? For example: The problem to be addressed (e.g., application of AI); the structure of the database on which the AI will be trained and will act; the training of the algorithm on the data; the algorithm itself; the results of the AI invention through an automated process; the policies/weights to be applied to the data that affects the outcome of the results; and/or other elements.

One of the USPTO's first challenges in addressing AI-generated inventions will be to establish appropriate definitions. An AI-generated invention should be defined as a "patentable invention generated by an AI in circumstances such that the AI, if a natural person, would be a patent inventor."

The definitions adopted by USPTO will help to provide certainty to discussions and policies and will also have substantive implications. For example, an AI-generated invention could also be defined as inventions made without a traditional human inventor. The definitions adopted by USPTO may impact subsistence, inventorship, and ownership of AI-generated inventions. Historically, AI-generated inventions have most commonly been referred to as "computer-generated works" (CGW), although a variety of other terms have been used such as "computational inventions." A variety of definitions have also been used for these terms. For example, CGWs are protected under United Kingdom's Copyright, Designs and Patents Act 1998 (CDPA), the UK's primary legislation for copyright law. The CDPA makes special provision for CGWs with different rules for authorship and copyright duration. These works are defined as those "generated by a computer in circumstances such that there is no human author of the work[s]." CDPA §178. For these works, the CDPA provides that, "[i]n the case of a literary, dramatic, musical or artistic work which is computer-generated, the author shall be taken to be the person by whom the arrangement necessary for the creation of the work are undertaken." CDPA §9(3).

By contrast, the definition I use for AI-generated works, and which I suggest the USPTO adopt, takes into account the fact that people and AI may work collaboratively and that even with the involvement of a human inventor an AI may functionally independently conceive of an invention. The rationale and support for this approach is discussed response to question 3 below.

In any event, AI-generated inventions should be clearly distinguished from AI inventions generally, as well as computer-implemented inventions and inventions that utilize AI, as they present distinct challenges requiring distinct policy solutions.

2. What are the different ways that a natural person can contribute to conception of an AI invention and be eligible to be a named inventor? For example: Designing the algorithm and/or weighting adaptations; structuring the data on which the algorithm runs; running the AI algorithm on the data and obtaining the results.

There are many ways that a person could conceive of an AI-generated invention. In some instances this may be the person(s) who identifies a problem, the person(s) who programs an AI to solve a particular problem, the person(s) who trains a connectionist AI on data, the person(s) who obtains, selects or verifies input data or training data, the person(s) who interprets AI output, and the person(s) who recognize the inventive nature of AI output.
Some of the time however, such individuals will not qualify as inventors. A programmer/developer/trainer who merely develops to an AI with problem-solving capabilities without *specifically* conceiving of a particular output should not qualify as an inventor. Considering a programmer an inventor is particularly problematic in cases where the programmer creates an AI without expectation or knowledge of the specific problems the AI will go on to solve. It is also more problematic in cases where an AI has been developed by a large and distributed group of programmers over a significant time frame. Further challenging programmer inventorship, some AI systems such as neural networks can behave unpredictably, such that their programmers may not understand precisely how they function. Other AIs, such as those based on genetic programming, may even be able to alter their own code. By analogy to human inventorship, a human inventor's teachers, mentors and even parents do not qualify as inventors on their patents – at least, not without directly contributing to the conception of a specific invention.

Attributing inventorship to an AI user, rather than a programmer, may also be problematic. It may sometimes be the case that a user makes an inventive contribution through the way that instructions have to be constructed for an AI, or that a user makes a significant contribution to an AI's output. However, it may also be the case that a user simply asks an AI to solve a problem, and the AI proceeds to independently generate an answer. Again, by analogy to human inventorship, simply instructing another person to solve a problem does not usually qualify for inventorship.

Finally, it may be the case that an individual conceives of an invention by recognizing the inventive subject matter of an AI's output. That may be appropriate where an AI generates numerous outputs and human judgment is needed to select a particular solution from a group of outputs. It may also be appropriate where inventive skill is needed to understand an AI's output. However, it may also be the case that the inventive nature of AI output is obvious and does not require inventive skill to identify. In these cases, it would be inappropriate to make a user an inventor.

Thus, in at least some instances, AIs are generating output traditionally entitled to patent protection under circumstances in which no natural person qualifies as an inventor according to traditional criteria. Or, an AI is acting as a co-inventor together with a person. In practice, it may be difficult to determine when a person or an AI, or both, have invented. However, this is not unlike making sense of human inventorship for joint inventions where individuals make diverse contributions.

There have been credible claims of AI creating AI-generate inventions for *decades* that have subsequently been granted patents, albeit without disclosure of the AI's role in the inventive process. (Abbott, 2019a; Abbott, 2016a). This has also been the case with the recent patent filings for AI-generated inventions. That AI, named DABUS, received only general training in basic conceptual information and proceeded to combine basic concepts independently into a complex idea that it self-identified as novel and salient. See, http://artificialinventor.com/.

3. Do current patent laws and regulations regarding inventorship need to be revised to take into account inventions where an entity or entities other than a natural person contributed to the conception of an invention?

Patent protection should be provided for AI-generated works to encourage innovation. As the U.S. Constitution states, Congress shall have the power to "promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries." U.S. CONST. art. I, § 8, cl. 8. This provides an explicit rationale for granting patent protection, namely to encourage innovation under an incentive theory. The theory goes that people will be more inclined to invent things (i.e., promote the progress of science) if they can receive government-sanctioned monopolies (i.e., patents) to exploit commercial embodiments of their inventions.

In the case of AI, even though machines do not care about patents, people who build, own, and use AI do. Allowing patents for AI-generated works would make inventive AI more valuable and incentivize the development of AI. This would reward effort upstream from the stage of invention and result in even more innovation. Patents on AI-generated inventions would have substantial value independent of patents on AI or computer-implemented inventions. Financial incentives may be particularly important for the development of inventive AI because producing such systems may be resource intensive. Allowing patents for AI-generated inventions would also avoid an inefficient outcome where a company has the option of more efficiently using an AI to generate inventive output but has to rely on human researchers to obtain patent protection.

Patents for AI-generated inventions would also achieve the other economic goals attributed to the patent system: incentivizing the disclosure of information and the commercialization and development of new inventions. AI-generated inventions may even be especially deserving of protection because inventive AI may be the only means of achieving certain discoveries that require the use of tremendous amounts of data or that deviate from conventional design wisdom.

If patents are to be granted for AI-generated inventions, particularly in cases where no natural person qualifies as an inventor, this then raises the questions of who, or what, should qualify as an inventor and who should own any subsequent patents.

The appropriate response to AI-generated inventions is to list an AI as an inventor and to have the AI's owner own any patents on its inventions. The AI should be listed as the inventor for several reasons. First, it is most accurate as the AI is functionally acting as an inventor. Second, it will facilitate appropriate attribution of ownership and chain of title. Third, and perhaps most importantly, it will protect the rights of inventors because it will prevent people from receiving undeserved acknowledgement. Taking credit for an AI's work would not be unfair to a machine, but it would diminish the accomplishments of people who have invented without using inventive AI. Finally, acknowledging AI as inventors would acknowledge AI developers, and it would reduce gamesmanship with the patent office.

AI inventorship should also apply to instances of joint invention with a natural person. There is no reason an AI's contribution should be ignored simply because a person is involved. Leaving out the AI would prevent an AI's owner from receiving the benefit of its property and may reduce the value of inventive AI—thus ultimately harming both investments in inventive AI as well as encouraging owners of inventive AI to limit access and sharing.

<u>Listing an AI as an inventor and having the AI's owner own subsequent patent rights is consistent with the Patent Clause of the Constitution as well as with existing patent laws</u>. U.S. CONST. art. I, § 8, cl. 8. USPTO should adopt a policy that adopts this approach to AI-generated inventions.

No US law explicitly prohibits patents on AI-generated works or prohibits the listing of an AI as an inventor. However, US patent law does refer to inventors as "individuals". *E.g.*, 35 U.S.C. § 100(f) ("The term 'inventor' means the individual or, if a joint invention, the individuals collectively who invented or discovered the subject matter of the invention."). The same issues surrounding computer inventorship may not exist outside of the U.S. where some jurisdictions, such as Israel, do not require a named inventor and where a non-natural person can apply for a patent as an applicant.

This "individual" language has been in place since at least the passage of legislation in 1952 that established the basic structure of modern patent law. It was included to protect the right of inventors to be acknowledged given that most patent applications are filed and owned by businesses. Legislators were not thinking about AI-generated inventions in 1952. *See* Karl F. Milde, Jr., Can a Computer Be an "Author" or an "Inventor"?, 51 J. PAT. OFF SOC'Y 378, 379 (1969) ("The closest that the Patent Statute comes to requiring that a patentee be an actual person is in the use, in Section 101, of the term "whoever." Here too, it is clear from the absence of any further qualifying statements that the Congress, in considering the statute in 1952, simply overlooked the possibility that a machine could ever become an inventor.").

Whether an AI can be an inventor in a constitutional sense is a question of first impression, and a dynamic interpretation of the law should thus allow AI inventorship. Such an approach would be consistent with the Founders' intent in enacting the Patent Clause to incentivize innovation, and it would interpret patent laws to further that purpose. Nor would such an interpretation run afoul of the chief objection to dynamic statutory interpretation, namely that it interferes with reliance and predictability and the ability of citizens "to be able to read the statute books and know their rights and duties." That is because a dynamic interpretation would not upset an existing policy; permitting AI inventors would allow additional patents rather than retroactively invalidate previously granted patents.

Other areas of patent law have been the subject of dynamic interpretation. For example, in the landmark 1980 case of Diamond v. Chakrabarty, the Supreme Court was charged with deciding whether genetically modified organisms could be patented. It held that a categorical rule denying patent protection for "inventions in areas not contemplated by Congress . . . would frustrate the purposes of the patent law." See Diamond v. Chakrabarty, 447 U. S. 303, 315

(1980). The court noted that Congress chose expansive language to protect a broad range of patentable subject matter.

Under that reasoning, AI inventorship should not be prohibited based on statutory text designed to deal with corporations. It would be particularly unwise to prohibit AI inventors on the basis of literal interpretations of texts written when AI-generated inventions were unforeseeable. If AI inventorship is to be prohibited, it should only be on the basis of sound public policy.

AI inventorship might also be objected to as incompatible with current laws on the basis that courts have historically referred to conception as a mental act. Conception has been defined as "the complete performance of the mental part of the inventive art," and it is "the formation in the mind of the inventor of a definite and permanent idea of the complete and operative invention as it is thereafter to be applied in practice." Townsend, 36 F.2d 292, 295 (C.C.P.A. 1929).

However, this should not prevent AI inventorship. The Patent Act does not mention a mental act, and courts have discussed mental activity largely from the standpoint of determining when an invention is actually made not whether it is inventive. In any case, whether or not AI "thinks" or has something analogous to consciousness should be irrelevant with regards to inventorship criteria.

The precise nature of a "mental act requirement" is unclear. Courts associating inventive activity with cognition have not been using terms precisely or meaningfully in the context of AI-generated inventions. It is unclear whether AI would have to engage in a process that results in creative output—which they do—or whether, and to what extent, they would need to mimic human thought. If the latter, it is unclear what the purpose of such a requirement would be except to exclude nonhumans (for which a convoluted test is unnecessary). Should a neural network-based AI be permitted to invent while a knowledge-based system is not? There is no principled reason for drawing that distinction, and a slippery slope exists in determining what constitutes a "thinking" AI even leaving aside deficits in our understanding of the structure and function of the human brain.

The primary reason a mental act requirement should not prevent AI inventorship is that the patent system should be indifferent to the means by which invention comes about. Congress came to this conclusion in 1952 when it abolished the Flash of Genius doctrine. That doctrine had been used by the Federal Courts as a test for patentability for over a decade. It held that in order to be patentable, a new device, "however useful it may be, must reveal the flash of creative genius, not merely the skill of the calling." Cuno Engineering Corp. v. Automatic Devices Corp. 314 U.S. 84, 91 (1941). The doctrine was interpreted to mean that an invention must come into the mind of an inventor in a "flash of genius" rather than as a "result of long toil and experimentation." Graham v. John Deere Co. of Kan. City, 383 U.S. 1, 15 n.7, 16 n.8 (1966). As a commentator at the time noted, "the standard of patentable invention represented by [the Flash of Genius doctrine] is apparently based upon the nature of the mental processes of the patentee-inventor by which he achieved the advancement in the art claimed in his patent, rather than solely upon the objective nature of the advancement itself." The "Flash of Genius" Standard of Patentable Invention, 13 FORDHAM L. REV. 84, 87 (1944).

The Flash of Genius test was an unhelpful doctrine because it was vague, difficult for lower courts to interpret, involved judges making subjective decisions about a patentee's state of mind, and made it substantially more difficult to obtain a patent. The test was part of a general hostility toward patents exhibited by mid-twentieth century courts, a hostility that caused United States Supreme Court Justice Robert Jackson to note in a dissent that "the only patent that is valid is one which this Court has not been able to get its hands on." Jungersen v. Ostby & Barton Co., 335 U.S. 560, 572 (1949) (Jackson, J., dissenting). Criticism of this state of affairs led President Roosevelt to establish a National Patent Planning Commission to study the patent system and to make recommendations for its improvement. In 1943, the Commission reported with regard to the Flash of Genius doctrine that "patentability shall be determined objectively by the nature of the contribution to the advancement of the art, and not subjectively by the nature of the process by which the invention may have been accomplished." The "Flash of Genius" Standard of Patentable Invention, 13 FORDHAM L. REV. 84, 85 (1944). Adopting this recommendation, the Patent Act of 1952 legislatively disavowed the Flash of Genius test. In the same manner, patentability of AI-generated inventions should be based on the inventiveness of an AI's output rather than on a clumsy anthropomorphism. Patent law should be interested in a functionalist solution—encouraging innovation.

Alternately, USPTO could elect to allow for patents on AI-generated inventions but adopt an alternate approach to inventorship such as deemed or imputed inventorship to a natural person, for instance allowing an AI's owner, user, or programmer to qualify as an inventor even when they do not traditionally meet inventorship criteria.

An AI cannot legally assign an invention but having patent ownership vest directly in an AI's owner as opposed to an inventor is consistent with general principles of property ownership.

4. Should an entity or entities other than a natural person, or company to which a natural person assigns an invention, be able to own a patent on the AI invention? For example: Should a company who trains the artificial intelligence process that creates the invention be able to be an owner?

Most patents today are owned by entities other than a natural person. Companies already account for the large majority of most patent applications in all major patent filing jurisdictions, including the United States. In the case of PCT applications, companies are applicants in around 85 percent of cases. https://www.wipo.int/edocs/pubdocs/en/wipo_pub_901_2019.pdf, pages 32–33.

In the event that a natural person is listed as an inventor, for an AI-generated invention or otherwise, the issue of ownership seems reasonably straightforward as inventors are default owners of their patents subject to any assignment obligations.

However, if an AI is listed as an inventor, an AI obviously cannot own a patent. Among other reasons, AI's lack legal personhood and cannot own property—in fact, AIs are owned as property. AI ownership of property would clearly be inappropriate.

Ownership rights to AI-generated inventions should vest in an AI's owner because it would be most consistent with the way personal property (including both AI and patents) is treated in the

United States and it would most incentivize AI invention. Ownership of patents on AI-generated inventions by an AI's owner could be taken as a starting point and parties would be able to contract around this default, and as AI inventions become more common, negotiations over these inventions may become a standard part of contract negotiations.

The most obvious alternate candidates for owners of such patents include an AI's programmer(s) and user(s). There may be some instances where ownership is more challenging on the basis that an AI is open-source, or distributed, etc. In cases where no AI owner exists, in possible cases of some open-source or distributed software, ownership could vest in a user or pass into the public domain.

5. Are there any patent eligibility considerations unique to AI inventions?

My comments have focused on AI-generated inventions, where USPTO should clarify that such inventions are patent eligible for earlier stated reasons.

6. Are there any disclosure-related considerations unique to AI inventions? For example, under current practice, written description support for computer-implemented inventions generally require sufficient disclosure of an algorithm to perform a claimed function, such that a person of ordinary skill in the art can reasonably conclude that the inventor had possession of the claimed invention. Does there need to be a change in the level of detail an applicant must provide in order to comply with the written description requirement, particularly for deep-learning systems that may have a large number of hidden layers with weights that evolve during the learning/training process without human intervention or knowledge?

For AI-generated inventions the relevant disclosure should be with respect to whether a skilled person could perform a claimed function of the invention applied for. How an AI generated the invention applied for should be irrelevant. We do not require human inventors to disclose their thought process with respect to generating an invention.

7. How can patent applications for AI inventions best comply with the enablement requirement, particularly given the degree of unpredictability of certain AI systems?

AI-generated inventions should be held to the same standard as other applications with respect to the invention applied for. Again, it should be irrelevant how the AI generated the invention, so long as the invention itself is sufficiently enabled.

8. Does AI impact the level of a person of ordinary skill in the art? If so, how? For example: Should assessment of the level of ordinary skill in the art reflect the capability possessed by AI?

The skilled person essentially represents the average worker in the field of an invention, and so the standard should evolve as the characteristics of average workers change over time. As AI comes to commonly *augment* the average researcher, the skilled person should be conceptualized as a skilled person using AI. AI can make a person more knowledgeable and sophisticated, so this should raise the PHOSITA bar.

With respect to augmenting the sophistication of average researchers, certain activities that once required inventive skill may become routine with the use of AI, such as modeling protein folding. With respect to augmenting the knowledge of average researchers, skilled persons are already presumed to have complete knowledge of prior art for purposes of Section 102, but for prior art to be combined for the purposes of obviousness, prior art must fall within the definition for anticipatory references under Section 102 and must additionally qualify as "analogous art." In re Bigio, 381 F.3d 1320, 1325 (Fed. Cir. 2004). That is to say, the prior art must be in the field of an applicant's endeavor, or reasonably pertinent to the problem with which the applicant was concerned. See, e.g., Wyers v. Master Lock Co., 616 F.3d 1231, 1237 (Fed. Cir. 2010). AI is likely to be less constrained with the extent to which it can leverage art in disparate fields, and so augmentation by AI should expand the scope of analogous art—eventually prior art for purposes of 102 and 103 should be the same.

The Federal Circuit has provided a list of nonexhaustive factors to consider in determining the level of ordinary skill: (1) "type[s] of problems encountered in the art," (2) "prior art solutions to those problems," (3) "rapidity with which innovations are made," (4) "sophistication of the technology," and (5) "educational level of active workers in the field." In re GPAC Inc., 57 F.3d 1573, 1579 (Fed. Cir. 1995). <u>This test should be modified to include a sixth factor: (6) "technologies used by active workers."</u>

Given continued advancements in AI it is likely that, at some point <u>**in the medium to long term future**</u>, AI will transition from *augmenting* human researchers to *automating* R&D—at least in some fields. This may happen, initially, in areas where AI has a comparative advantage such as discovering new uses of existing drugs from pattern recognition in large data sets. If the PHOSITA standard fails to reflect the capability possessed by AI, then once the average worker routinely uses inventive AI, or inventive AI replaces the average worker, then inventive activity will be normal instead of exceptional. This will result in too lenient a standard for patentability. Allowing the average worker to routinely patent their outputs would cause social harm. As the U.S. Supreme Court has articulated, "[g]ranting patent protection to advances that would occur in the ordinary course without real innovation retards progress and may . . . deprive prior inventions of their value or utility." KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 402 (2007).

Once inventive AI becomes the standard means of research in a field, considering the skilled person as a skilled person using AI would also encompass the routine use of inventive AI by average workers. Taken a step further, once inventive AI becomes the standard means of research in a field, the skilled person should be an inventive AI. Specifically, the skilled person should be an inventive AI when the standard approach to research in a field or with respect to a particular problem is to use an inventive AI (the "Inventive AI Standard"). Conceptualizing the skilled person as using a skilled person using AI might be administratively simpler but replacing the skilled person with the inventive AI would be preferable because it emphasizes that the AI is engaging in inventive activity, rather than the human worker.

To obtain the necessary information to implement this test, the USPTO should establish a new requirement for applicants to disclose when an AI contributes to the conception of an invention, which is the standard for qualifying as an inventor. Applicants are already required to disclose all human inventors, and failure to do so can render a patent invalid or unenforceable. Similarly, applicants should need to disclose whether an AI has done the work of a human inventor. This information could be aggregated to determine whether most invention in a field is performed by people or AI. This information would also be useful for determining appropriate inventorship, and more broadly for formulating innovation policies.

Yet simply substituting an inventive AI for a skilled person might exacerbate existing problems with the nonobviousness inquiry. With the current skilled person standard, decisionmakers, in hindsight, need to reason about what another person would have found obvious. This results in inconsistent and unpredictable nonobviousness determinations. In practice, the skilled person standard bears unfortunate similarities to the "Elephant Test," or Justice Stewart's famously unworkable definition of obscene material: "I know it when I see it." This may be even more problematic in the case of inventive AI, as it is likely to be difficult for human decisionmakers to theoretically reason about what an AI would find obvious.

An existing vein of critical scholarship has already advocated for nonobviousness inquiries to focus more on economic factors or objective "secondary" criteria, such as long-felt but unsolved needs, the failure of others, and real-world evidence of how an invention was received in the marketplace. Inventive AI may provide the impetus for such a shift. Nonobvious inquiries utilizing the Inventive AI Standard might also focus on reproducibility, specifically whether standard AI could reproduce the subject matter of a patent application with sufficient ease. This could be a more objective and determinate test that would allow the Patent Office to apply a single standard consistently, and it would result in fewer judicially invalidated patents. A nonobviousness inquiry focused on either secondary factors or reproducibility may avoid some of the difficulties inherent in applying a "cognitive" Inventive AI Standard.

However the test is applied, an Inventive AI Standard will dynamically raise the current benchmark for patentability. Inventive AI will be significantly more intelligent than skilled persons and also capable of considering more prior art. An Inventive AI Standard would not prohibit patents, but it would make obtaining them substantially more difficult: A person or AI might need to have an unusual insight that other inventive AI could not easily recreate, developers might need to create increasingly intelligent AI that could outperform standard AI, or, most likely, invention will be dependent on specialized, non-public sources of data. The nonobviousness bar will continue to rise as AI inevitably become increasingly sophisticated. Taken to its logical extreme, and given there may be no limit to how intelligent AI will become, it may be that every invention will one day be obvious to commonly used AI. That would mean no more patents should be issued without some radical change to current patentability criteria.

Please refer to Abbott 2019a which is directed at these questions in greater detail.

9. Are there any prior art considerations unique to AI inventions?

No comment at this time.

10. Are there any new forms of intellectual property protections that are needed for AI inventions, such as data protection?

No comment at this time.

<u>11. Are there any other issues pertinent to patenting AI inventions that we should examine?</u>

No comment at this time.

<u>12. Are there any relevant policies or practices from other major patent agencies that may help inform USPTO's policies and practices regarding patenting of AI inventions?</u>

The European Patent Office (EPO), United Kingdom Intellectual Property Office (UKIPO) and the World Intellectual Property Office (WIPO) have all been active with respect to patenting AI inventions in the past several years. Some of these efforts are linked to at: http://artificialinventor.com/resources/.

<u>Conclusion</u>

Advances in AI pose new challenges to intellectual property systems designed to incentive and protect acts of human creativity. These developments will require us to not only reconsider how existing blackletter law can accommodate new technological developments, but also the normative foundations of our intellectual property systems.

The guiding principle for the USPTO should be what rules will best achieve the underlying goals of patent law. Namely, how can patent law best incentivize innovation and protect the rights of inventors. With respect to AI, USPTO should be concerned with the functionality of machines and their consequentialist benefits. What legal rules will result in the greatest social benefit from technologies like AI? At the end of the day, the primary purpose of the patent system is to promote innovation, whether it comes from a machine or a person.

It is important the US adopt policies that allow patents on AI-generated works. This will encourage development of inventive AI, ultimately resulting in new innovation. Even if inventive AI currently plays a relatively small role in R&D, this is very likely to change as a result of continued advances in AI. Inventive AI may soon become a major contributor to innovation and generate a substantial amount of social benefit. I submit that the best way to appropriately encourage this, to ensure the U.S. remains a globally competitive nation, and to protect the moral rights of inventors, is to list an AI as an inventor where it functionally automates invention and for any ownership rights in patents for AI-generated inventions to vest in an AI’s owner.

Respectfully Submitted,

Ryan Abbott, MD, JD, MTOM

U.C.L.A. Law Review

Everything Is Obvious

Ryan Abbott

ABSTRACT

For more than sixty years, "obviousness" has set the bar for patentability. Under this standard, if a hypothetical "person having ordinary skill in the art" would find an invention obvious in light of existing relevant information, then the invention cannot be patented. This skilled person is defined as a non-innovative worker with a limited knowledge-base. The more creative and informed the skilled person, the more likely an invention will be considered obvious. The standard has evolved since its introduction, and it is now on the verge of an evolutionary leap: Inventive machines are increasingly being used in research, and once the use of such machines becomes standard, the person skilled in the art should be a person using an inventive machine, or just an inventive machine. Unlike the skilled person, the inventive machine is capable of innovation and considering the entire universe of prior art. As inventive machines continue to improve, this will increasingly raise the bar to patentability, eventually rendering innovative activities obvious. The end of obviousness means the end of patents, at least as they are now.

AUTHOR

Professor of Law and Health Sciences, University of Surrey School of Law and Adjunct Assistant Professor, David Geffen School of Medicine at University of California, Los Angeles. Thanks to Ryan Calo, Ian Kerr, Mark Lemley, Lisa Larrimore-Ouellette, and Jake Sherkow, as well as participants in workshops at the University of Surrey, WeRobot Conference, Oxford Business Law Workshop, and the Sixth Annual Fall Conference hosted by the Center for the Protection of Intellectual Property (CPIP) at Antonin Scalia Law School for their insightful comments.

TABLE OF CONTENTS

INTRODUCTION

For at least two decades, machines have been autonomously generating patentable inventions.[1] "Autonomously" here refers to the machine, rather than to a person, meeting traditional inventorship criteria. In other words, if the "inventive machine" were a natural person, it would qualify as a patent inventor. In fact, the U.S. Patent and Trademark Office (USPTO or Patent Office) may have granted patents for inventions autonomously generated by computers as early as 1998.[2] In earlier articles, I examined instances of autonomous machine invention in detail and argued that such machines ought to be legally recognized as patent inventors to incentivize innovation and promote fairness.[3] The owners of such machines would be the owners of their inventions.[4] In those works, as here, terms such as "computers" and "machines" are used interchangeably to refer to computer programs or software rather than to physical devices or hardware.[5]

This Article focuses on a related phenomenon: What happens when inventive machines become a standard part of the inventive process? This is not a thought experiment.[6] For instance, while the timeline is controversial, surveys of experts suggest that artificial general intelligence, which is a computer able to perform any intellectual task a person could, will develop in the next twenty-five years.[7] Some thought leaders, such as Ray Kurzweil, one of Google's Directors of

---

1. *See* Ryan Abbott, *I Think, Therefore I Invent: Creative Computers and the Future of Patent Law*, 57 B.C. L. REV. 1079, 1083–91 (2016) [hereinafter *I Think*] (describing instances of "computational invention" or "computer-generated works"); *see also infra* Subpart II.B (discussing some such instances in greater detail).
2. Abbott, *supra* note 1, at 1085.
3. *Id.* at 1083–91; Ryan Abbott, *Hal the Inventor: Big Data and Its Use by Artificial Intelligence*, *in* BIG DATA IS NOT A MONOLITH (Cassidy R. Sugimoto, Hamid R. Ekbia & Michael Mattioli eds.,2016) [hereinafter *Hal the Inventor*] (discussing computational invention in a book chapter first posted online February 19, 2015).
4. Except where no owner exists, in possible cases of some open-source or distributed software, in which case ownership could vest in a user.
5. Except perhaps in exceptional cases where software does not function on a general-purpose machine, and where specialized hardware is required for the software's function.
6. The growing prevalence and sophistication of artificial intelligence is accelerating the use of inventive machines in research and development. *See* Ryan Abbott & Bret Bogenschneider, *Should Robots Pay Taxes? Tax Policy in the Age of Automation*, 12 HARV. L. & POL'Y REV. 145 (2018) [hereinafter *Should Robots Pay Taxes?*] (discussing the trend toward automation).
7. *See generally* Vincent C. Müller & Nick Bostrom, *Future Progress in Artificial Intelligence: A Survey of Expert Opinion*, *in* FUNDAMENTAL ISSUES OF ARTIFICIAL INTELLIGENCE 553 (Vincent C. Müller ed., 2016).

Engineering, predict computers will have human levels of intelligence in about a decade.[8]

The impact of the widespread use of inventive machines will be tremendous, not just on innovation, but also on patent law.[9] Right now, patentability is determined based on what a hypothetical, non-inventive, skilled person would find obvious.[10] The skilled person represents the average worker in the scientific field of an invention.[11] Once the average worker uses inventive machines, or inventive machines replace the average worker, then inventive activity will be normal instead of exceptional.

If the skilled person standard fails to evolve accordingly, this will result in too lenient a standard for patentability. Patents have significant anticompetitive costs, and allowing the average worker to routinely patent their outputs would cause social harm. As the U.S. Supreme Court has articulated, "[g]ranting patent protection to advances that would occur in the ordinary course without real innovation retards progress and may . . . deprive prior inventions of their value or utility."[12]

The skilled standard must keep pace with real world conditions. In fact, the standard needs updating even before inventive machines are commonplace. Already, computers are widely facilitating research and assisting with invention. For instance, computers may perform literature searches, data analysis, and pattern recognition.[13] This makes current workers more knowledgeable and creative than they would be without the use of such technologies. The Federal Circuit has provided a list of nonexhaustive factors to consider in determining the level of ordinary skill: (1) "type[s] of problems encountered in the art," (2) "prior art solutions to those problems," (3) "rapidity with which innovations are made," (4) "sophistication of the technology," and (5) "educational level of active

8. Peter Rejcek, *Can Futurists Predict the Year of the Singularity?*, SINGULARITY HUB (Mar. 31, 2017), https://singularityhub.com/2017/03/31/can-futurists-predict-the-year-of-the-singularity [https://perma.cc/4TDE-QQTW] (predicting artificial general intelligence in 2029).

9. *See, e.g.*, ROBERT PLOTKIN, THE GENIE IN THE MACHINE: HOW COMPUTER-AUTOMATED INVENTING IS REVOLUTIONIZING LAW & BUSINESS 60 (2009) (arguing that "[a]rtificial invention technology . . . enables [users] to produce inventions that they could not have created *at all* without such technology"); Ben Hattenbach & Joshua Glucoft, *Patents in an Era of Infinite Monkeys and Artificial Intelligence*, 19 STAN. TECH. L. REV. 32, 44 n.70 (2015); Brenda M. Simon, *The Implications of Technological Advancement for Obviousness*, 19 MICH. TELECOMM. & TECH. L. REV. 331 (2013).

10. 35 U.S.C. § 103(a) (2006). The "person having ordinary skill in the art" may be abbreviated as "PHOSITA" or simply the skilled person.

11. *See infra* Subpart I.D.

12. KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 402 (2007).

13. Such contributions when made by other persons do not generally rise to the level of inventorship, but they assist with reduction to practice.

workers in the field."[14] This test should be modified to include a sixth factor: (6) "technologies used by active workers."

This change will more explicitly take into account the fact that machines are already augmenting the capabilities of workers, in essence making more obvious and expanding the scope of prior art. Once inventive machines become the standard means of research in a field, the test would also encompass the routine use of inventive machines by skilled persons. Taken a step further, once inventive machines become the standard means of research in a field, the skilled person should be an inventive machine. Specifically, the skilled person should be an inventive machine when the standard approach to research in a field or with respect to a particular problem is to use an inventive machine (the "Inventive Machine Standard").

To obtain the necessary information to implement this test, the Patent Office should establish a new requirement for applicants to disclose when a machine contributes to the conception of an invention, which is the standard for qualifying as an inventor. Applicants are already required to disclose all human inventors, and failure to do so can render a patent invalid or unenforceable. Similarly, applicants should need to disclose whether a machine has done the work of a human inventor. This information could be aggregated to determine whether most invention in a field is performed by people or machines. This information would also be useful for determining appropriate inventorship, and more broadly for formulating innovation policies.

Whether the Inventive Machine Standard is that of a skilled person using an inventive machine or just an inventive machine, the result will be the same: The average worker will be capable of inventive activity. Conceptualizing the skilled person as using an inventive machine might be administratively simpler, but replacing the skilled person with the inventive machine would be preferable because it emphasizes that the *machine* is engaging in inventive activity, rather than the human worker.

Yet simply substituting an inventive machine for a skilled person might exacerbate existing problems with the nonobviousness inquiry. With the current skilled person standard, decisionmakers, in hindsight, need to reason about what another person would have found obvious.[15] This results in

14. *In re* GPAC Inc., 57 F.3d 1573, 1579 (Fed. Cir. 1995).
15. *See generally* Gregory N. Mandel, *Patently Non-Obvious: Empirical Demonstration that the Hindsight Bias Renders Patent Decisions Irrational*, 67 OHIO ST. L.J. 1391 (2006) (discussing problems with hindsight in non-obviousness inquiries).

inconsistent and unpredictable nonobviousness determinations.[16] In practice, the skilled person standard bears unfortunate similarities to the "Elephant Test,"[17] or Justice Stewart's famously unworkable definition of obscene material: "I know it when I see it."[18] This may be even more problematic in the case of inventive machines, as it is likely to be difficult for human decisionmakers to theoretically reason about what a machine would find obvious.

An existing vein of critical scholarship has already advocated for nonobviousness inquiries to focus more on economic factors or objective "secondary" criteria, such as long-felt but unsolved needs, the failure of others, and real-world evidence of how an invention was received in the marketplace.[19] Inventive machines may provide the impetus for such a shift.

Nonobvious inquiries utilizing the Inventive Machine Standard might also focus on *reproducibility*, specifically whether standard machines could reproduce the subject matter of a patent application with sufficient ease. This could be a more objective and determinate test that would allow the Patent Office to apply a single standard consistently, and it would result in fewer judicially invalidated patents.[20] A nonobviousness inquiry focused on either secondary

16. *See* FED. TRADE COMM'N, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY 6–15 (2003) (critiquing Section 103 decisions).
17. Cadogan Estates Ltd. v. Morris [1998] EWCA Civ. 1671 at 17 (Eng.) (referring to "the well known elephant test. It is difficult to describe, but you know it when you see it").
18. 378 U.S. 184, 197 (1964).
19. *See, e.g.*, Michael Abramowicz & John F. Duffy, *The Inducement Standard of Patentability*, 120 YALE L.J. 1590, 1596 (2011) (arguing for an inducement standard); Tun-Jen Chiang, *A Cost-Benefit Approach to Patent Obviousness*, 82 ST. JOHN'S L. REV. 39, 42 (2008) (arguing that, "[a]n invention should receive a patent if the accrued benefits before independent invention outweigh the costs after independent invention"); Alan Devlin & Neel Sukhatme, *Self-Realizing Inventions and the Utilitarian Foundation of Patent Law*, 51 WM. & MARY L. REV. 897 (2009); John F. Duffy, *A Timing Approach to Patentability*, 12 LEWIS & CLARK L. REV. 343 (2008) (arguing for a timing approach to determining obviousness); Daralyn J. Durie & Mark A. Lemley, *A Realistic Approach to the Obviousness of Inventions*, 50 WM. & MARY L. REV. 989, 1004–07 (2008) (arguing for a greater reliance on secondary considerations); Gregory Mandel, *The Non-Obvious Problem: How the Indeterminate Nonobviousness Standard Produces Excessive Patent Grants*, 42 U.C. DAVIS L. REV 57, 62 (2008) [hereinafter Mandel, *The Non-Obvious Problem*] (arguing for nonobviousness to be based on "how probable the invention would have been for a person having ordinary skill in the art working on the problem that the invention solves"); Robert P. Merges, *Uncertainty and the Standard of Patentability*, 7 HIGH TECH. L.J. 1, 19 (1992) (arguing that patents should be issued for inventions which appeared unlikely to succeed in advance).
20. For decades, obviousness has been the most common issue in litigation to invalidate a patent, and the most common grounds for a finding of patent invalidity. *See* John R. Allison & Mark A. Lemley, *Empirical Evidence on the Validity of Litigated Patents*, 26 AIPLA Q.J. 185, 208–09 (1998); John R. Allison et al., *Understanding the Realities of Modern Patent Litigation*, 92 TEX. L. REV. 1769, 1782, 1785 (2014). As other commentators have noted, the bar here is low, and the new standard, "can be an administrative success if it is even just a bit

factors or reproducibility may avoid some of the difficulties inherent in applying a "cognitive" inventive machine standard.

However the test is applied, the Inventive Machine Standard will dynamically raise the current benchmark for patentability. Inventive machines will be significantly more intelligent than skilled persons and also capable of considering more prior art. An Inventive Machine Standard would not prohibit patents, but it would make obtaining them substantially more difficult: A person or computer might need to have an unusual insight that other inventive machines could not easily recreate, developers might need to create increasingly intelligent computers that could outperform standard machines, or, most likely, invention will be dependent on specialized, non-public sources of data. The nonobviousness bar will continue to rise as machines inevitably become increasingly sophisticated. Taken to its logical extreme, and given there may be no limit to how intelligent computers will become, it may be that every invention will one day be obvious to commonly used computers. That would mean no more patents should be issued without some radical change to current patentability criteria.

This Article is structured in three parts. Part I considers the current test for obviousness and its historical evolution. It finds that obviousness is evaluated through the lens of the skilled person, who reflects the characteristics of the average worker in a field.[21] The level of creativity and knowledge imputed to the skilled person is critical for the obviousness analysis.[22] The more capable the skilled person, the more they will find obvious, and this will result in fewer issued patents.

Part II considers the use of artificial intelligence in research and development (R&D) and proposes a novel framework for conceptualizing the transition from human to machine inventors. Already, inventive machines are competing with human inventors, and human inventors are augmenting their

better than current doctrine as a helpful theoretical and pragmatic guide for applying the obviousness doctrine." Abramowicz & Duffy, *supra* note 19, at 1601.

21. *See* Ruiz v. A.B. Chance Co., 234 F.3d 654, 666 (Fed. Cir. 2000); *see also* Ryko Mfg. Co. v. Nu-Star, Inc., 950 F.2d 714, 718 (Fed. Cir. 1991) ("The importance of resolving the level of ordinary skill in the art lies in the necessity of maintaining objectivity in the obviousness inquiry."). The Manual of Patent Examining Procedure (MPEP) provides guidance on the level of ordinary skill in the art. MPEP § 2141.03.

22. DyStar Textilfarben GmbH & Co. Deutschland KG v. C.H. Patrick Co., 464 F.3d 1356, 1370 (Fed. Cir. 2006) ("If the level of skill is low, for example that of a mere dyer, as Dystar has suggested, then it may be rational to assume that such an artisan would not think to combine references absent explicit direction in a prior art reference."). Though, in practice, few cases involve explicit factual determinations of the PHOSITA's skill. Rebecca S. Eisenberg, *Obvious to Whom? Evaluating Inventions From the Perspective of PHOSITA*, 19 BERKELEY TECH. L.J. 885, 888 (2004). See *infra* Subpart I.D for a discussion of the PHOSITA standard.

abilities with inventive machines. In time, inventive machines or people using inventive machines will become the standard in a field, and eventually, machines will be responsible for most or all innovation. As this occurs, the skilled person standard must evolve if it is to continue to reflect real-world conditions. Failure to do this would "stifle, rather than promote, the progress of the useful arts."[23]

Part II then proposes a framework for implementing a proposed Inventive Machine Standard. A decisionmaker would need to (1) determine the extent to which inventive machines are used in a field, (2) if inventive machines are the standard, characterize the inventive machine(s) that best represents the average worker, and (3) determine whether the machine(s) would find an invention obvious. The decisionmaker is a patent examiner in the first instance,[24] and potentially a judge or jury if the validity of a patent is at issue in trial.[25] In both instances, this new test would involve new challenges.

Finally, Part III provides examples of how the Inventive Machine Standard could work in practice, such as by focusing on reproducibility or secondary factors. It then goes on to consider some of the implications of the new standard. Once the average worker is inventive, there may no longer be a need for patents to function as innovation incentives. To the extent patents accomplish other goals such as promoting commercialization and disclosure of information or validating moral rights, other mechanisms may be found to accomplish these goals with fewer costs.

Although this Article focuses on U.S. patent law, a similar framework exists in nearly every country. Member States of the World Trade Organization (WTO) are required to grant patents for inventions that "are new, involve an

23. *KSR Int'l Co.*, 550 U.S. at 427.

24. At the Patent Office, applications are initially considered by a patent examiner, and examiner decisions can be appealed to the Patent Trial and Appeal Board (PTAB). U.S. Patent & Trademark Office, *Patent Trial and Appeal Board*, https://www.uspto.gov/patents-application-process/patent-trial-and-appeal-board-0 [https://perma.cc/3W42-FHH2]. Also, the PTAB can adjudicate issues of patentability in certain proceedings such as inter partes review. *Id.*

25. Determinations of patent validity can involve mixed questions of law and fact. Generally, in civil litigation, legal questions are determined by judges, while factual questions are for a jury. *See, e.g.*, Structural Rubber Prods. Co. v. Park Rubber Co., 749 F.2d 707, 713 (Fed. Cir. 1984) ("Litigants have the right to have a case tried in a manner which ensures that factual questions are determined by the jury and the decisions on legal issues are made by the court . . . ."). There are some exceptions to this rule. *See, e.g.*, Gen. Electro Music Corp. v. Samick Music Corp., 19 F.3d 1405, 1408 (Fed. Cir. 1994) ("[I]ssues of fact underlying the issue of inequitable conduct are not jury questions, the issue being entirely equitable in nature."). *See also* Mark A. Lemley, *Why Do Juries Decide If Patents Are Valid?* (Stanford Pub. Law, Working Paper No. 2306152, 2013), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2306152.

inventive step and are capable of industrial application."[26] Although U.S. law uses the term "nonobvious" rather than "inventive step," the criteria are substantively similar.[27] For instance, the European Patent Office's criteria for inventive step is similar to the U.S. criteria for obviousness, and also uses the theoretical device of the skilled person.[28]

I. OBVIOUSNESS

Part I investigates the current obviousness standard, its historical origins, and how the standard has changed over time. It finds that obviousness depends on the creativity of the skilled person, as well as the prior art they consider. These factors, in turn, vary according to the complexity of an invention and its field of art.

A. Public Policy

Patents are not intended to be granted for incremental inventions.[29] Only inventions which represent a significant advance over existing technology should receive protection.[30] That is because patents have significant costs: They limit competition, and they can inhibit future innovation by restricting the use

26. Agreement on Trade-Related Aspects of Intellectual Property Rights, art. 27, Apr. 15, 1994, 33 I.L.M. 1197, 1208 [hereinafter TRIPS]. *See* Ryan B. Abbott, et al., *The Price of Medicines in Jordan: The Cost of Trade-Based Intellectual Property*, 9 J. GENERIC MEDS. 75, 76 (2012).
27. TRIPS, *supra* note 26, at 1208 n.5. Although, there are some substantive differences in the way these criteria are implemented, and TRIPS provides nations with various flexibilities for compliance. *See generally* Ryan Abbott, *Balancing Access and Innovation in India's Shifting IP Regime, Remarks*, 35 WHITTIER L. REV. 341 (2014) [hereinafter *Balancing Access*].
28. "An invention shall be considered as involving an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art." Convention on the Grant of European Patents art. 56, Oct. 5, 1973, 13 I.L.M 268. For guidance on the "skilled person" in European patent law, see *Guidelines for Examinations*, EUR. PAT. OFF., http://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_vii_3.htm [https://perma.cc/XFY3-JD8J] (last visited Sept. 24, 2018).
29. The nonobviousness requirement is contained in Section 103 of the Patent Act:

    > A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains.

    35 U.S.C. § 103 (2018).
30. Atlantic Works v. Brady, 107 U.S. 192, 200 (1883) (noting that "[t]o grant to a single party monopoly of every slight advance made, except where the exercise of invention, somewhat above ordinary mechanical or engineering skill, is distinctly shown, is unjust in principle and injurious in its consequences").

of patented technologies in research and development.[31] To the extent that patents are justified, it is because they are thought to have more benefits than costs. Patents can function as innovation incentives, promote the dissemination of information, encourage commercialization of technology, and validate moral rights.[32]

Patents are granted for inventions that are new, nonobvious, and useful.[33] Of these three criteria, obviousness is the primary hurdle for most patent applications.[34] Although other patentability criteria contribute to this function, the nonobviousness requirement is the primary test for distinguishing between significant innovations and trivial advances.[35] Of course, it is one thing to express a desire to only protect meaningful scientific advances, and another to come up with a workable rule that applies across every area of technology.

B. Early Attempts

The modern obviousness standard has been the culmination of hundreds of years of struggle by the Patent Office, courts, and Congress to separate the wheat from the chaff.[36] As Thomas Jefferson, the first administrator of the U.S.

---

31. *See I Think*, *supra* note 1, at 1105–06 (discussing the costs and benefits of the patent system).
32. *Id.* at 1105–08. Congress's power to grant patents is constitutional, and based on incentive theory: "To promote the progress of science . . . by securing for limited times to . . . inventors the exclusive right to their respective . . . discoveries." U.S. CONST. art. I, § 8, cl. 8. *See* Mark A. Lemley, *Ex Ante Versus Ex Post Justifications for Intellectual Property*, 71 U. CHI. L. REV. 129, 129 (2004) ("The standard justification for intellectual property is ex ante . . . . It is the prospect of the intellectual property right that spurs creative incentives."); *see also* United States v. Line Material Co., 333 U.S. 287, 316 (1948) (Douglas, J., concurring) (noting "the reward to inventors is wholly secondary" to the reward to society); THE FEDERALIST NO. 43 (James Madison) (stating that social benefit arises from patents to inventors). The U.S. Supreme Court has endorsed an economic inducement rationale in which patents should only be granted for inventions which would "not be disclosed or devised but for the inducement of a patent." This is the inducement theory articulated in *Graham v. John Deere Co.*, 383 U.S. 1, 10 (1966). *See also* Abramowicz & Duffy, *supra* note 20.
33. 35 U.S.C. §§ 101–103, 112 (2018). In the European system, these criteria are referred to as novelty, inventive step, and industrial applicability. Art. 52 EPC. Inventions must also comprise patentable subject matter and be adequately disclosed. 35 U.S.C. §§ 101–103, 112 (2018).
34. DONALD CHISUM, CHISUM ON PATENTS § 5.02[6] (2007); NONOBVIOUSNESS—THE ULTIMATE CONDITION OF PATENTABILITY 2:101 (J. Witherspoon ed., 1980). Obviousness is the most commonly litigated issue of patent validity. Allison & Lemley, *supra* note 20, at 208–09 (1998).
35. 35 U.S.C. §§ 101–102, 112 (2018).
36. For that matter, the struggle dates back to the very first patent law, the Venetian Act of 1474, which stated that only "new and ingenious" inventions would be protected. *See* Giulio Mandich, *Venetian Patents (1450–1550)*, 30 J. PAT. OFF. SOC'Y 166, 176–77 (1948); A. Samuel Oddi, *Beyond Obviousness: Invention Protection in the Twenty-First Century*, 38 AM.

patent system and one of its chief architects, wrote, "I know well the difficulty of drawing a line between the things which are worth to the public the embarrassment of an exclusive patent, and those which are not . . . I saw with what slow progress a system of general rules could be matured."[37]

The earliest patent laws focused on novelty and utility, although Jefferson did at one point suggest an "obviousness" requirement.[38] The Patent Act of 1790 was the first patent statute, and it required patentable inventions to be "sufficiently useful and important."[39] Three years later, a more comprehensive patent law was passed—the Patent Act of 1793.[40] The new act did not require an invention to be "important," but required it to be "new and useful."[41] The 1836 Patent Act reinstated the requirement that an invention be "sufficiently used and important."[42]

In 1851, the Supreme Court adopted the progenitor of the skilled person and the obviousness test—an "invention" standard.[43] *Hotchkiss v. Greenwood*

U. L. REV. 1097, 1102–03 (1989); Frank D. Prager, *A History of Intellectual Property From 1545 to 1787*, 26 J. PAT. OFF. SOC'Y 711, 715 (1944).

37. Letter to Isaac McPherson (Aug. 13, 1813), *in* 5 THE WRITINGS OF THOMAS JEFFERSON, 1790–1826, 175, 181 (Riker, Thorne & Co. 1854) [hereinafter Letter to Isaac McPherson].

38. In 1791, Jefferson proposed amending the 1790 Patent Act to prohibit patents on an invention if it "is so unimportant and obvious that it ought not be the subject of an exclusive right." 5 THE WRITINGS OF THOMAS JEFFERSON 278, 1788–1792, (Paul Leicester Ford ed., G.P. Putnam & Sons 1895).

39. Patent Act of 1790, ch. 7, 1 Stat. 109 (repealed 1793).

40. Patent Act of 1793, ch. 11, 1 Stat. 318 (repealed 1836).

41. Patent Act of 1793, ch. 11, 1 Stat. at 318–23. It also prohibited patents on certain minor improvements: "[S]imply changing the form or the proportions of any machine, or compositions of matter, in any degree, shall not be deemed a discovery." *Id.* at 321. On this basis, Jefferson, who was credited with drafting most of this statute, argued that "[a] change of material should not give title to a patent. As the making a ploughshare of cast rather than of wrought iron; a comb of iron, instead of horn or of ivory . . . ." Letter to Isaac McPherson, *supra* note 37, at 181.

42. Patent Act of 1836, ch. 357, § 18, 5 Stat. 117, 124 (repealed 1861).

43. *See, e.g.*, Graham v. John Deere Co., 383 U.S. 1, 17 (1966) ("We conclude that [§ 103] was intended merely as a codification of judicial precedents embracing the Hotchkiss condition, with congressional directions that inquiries into the obviousness of the subject matter sought to be patented are a prerequisite to patentability."); *see also* S. REP. NO. 82-1979, at 6 (1952); H.R. REP. NO. 82-1923, at 7 (1952) ("Section 103 . . . provides a condition which exists in the law and has existed for more than 100 years."). Obviousness had been at issue in earlier cases, although not necessarily in such terms. For instance, in *Earle v. Sawyer*, Justice Story rejected an argument by the defendant that the invention at issue was obvious, and that something more than novelty and utility was required for a patent. 8 F. Cas. 254, 255 (Cir. Ct. D. Mass. 1825). He argued a court was not required to engage in a "mode of reasoning upon the metaphysical nature, or the abstract definition of an invention." *Id.* Justice Story further noted that English law permits the introducer of a foreign technology to receive a patent, and such an act could not require intellectual labor. *Id.* at 256. In *Evans v. Eaton*, the Supreme Court held that, a patent invention must involve a change in the "principle" of the machine rather than a change "merely in form and proportion." 20 U.S.

concerned a patent for substituting clay or porcelain for a known door knob material such as metal or wood.[44] The Court invalidated the patent, holding that "the improvement is the work of a skillful mechanic, not that of the inventor."[45] The Court also articulated a new legal standard for patentability: "Unless more ingenuity and skill . . . were required . . . than were possessed by an ordinary mechanic acquainted with the business, there was an absence of that degree of skill and ingenuity which constitute essential elements of every invention."[46]

However, the Court did not give specific guidance on what makes something inventive or the required level of inventiveness. In subsequent years, the Court made several efforts to address these deficiencies, but with limited success. As the Court stated in 1891, "[t]he truth is the word [invention] cannot be defined in such manner as to afford any substantial aid in determining whether any particular device involves an exercise of inventive faculty or not."[47] Or as one commentator noted, "it was almost impossible for one to say with any degree of certainty that a particular patent was indeed valid."[48]

Around 1930, the Supreme Court, possibly influenced by a national antimonopoly sentiment, began implementing stricter criteria for determining the level of invention.[49] This culminated in the widely disparaged "Flash of Genius" test articulated in *Cuno Engineering v. Automatic Devices Corp*.[50] Namely, that in order to receive a patent, "the new device must reveal the flash of creative genius, not merely the skill of the calling."[51] This test was interpreted to mean that an invention must come into the mind of an inventor as a result of

---

(7 Wheat) 356, 361–62 (1822). Writing for the Court, Justice Story noted the patent was invalid because it was "substantially the same in principle" as a prior invention. *Id.* at 362.

44. 52 U.S. 248, 265 (1850).
45. *Id.* at 267.
46. *Id.*
47. McClain v. Ortmayer, 141 U.S. 419, 427 (1891). Another court noted that "invention" is "as fugitive, impalpable, wayward, and vague a phantom as exists in the paraphernalia of legal concepts." Harries v. Air King Prods. Co., 183 F.2d 158, 162 (2d Cir. 1950).
48. Gay Chin, *The Statutory Standard of Invention: Section 103 of the 1952 Patent Act*, 3 PAT. TRADEMARK & COPY. J. RES. & EDUC. 317, 318 (1959).
49. *See, e.g.*, Edward B. Gregg, *Tracing the Concept of Patentable Invention*, 13 VILL. L. REV. 98 (1967).
50. Cuno Eng'g Corp. v. Automatic Devices Corp., 314 U.S. 84, 91 (1941) (formalizing the test). *See, e.g.*, Hamilton Standard Propeller Co. v. Fay-Egan Mfg. Co., 101 F.2d 614, 617 (6th Cir. 1939) ("The patentee did not display any flash of genius, inspiration or imagination . . . ."). The Flash of Genius test was reaffirmed by the Court in 1950 in *Great Atlantic & Pacific Tea Co. v. Supermarket Equip. Corp.*, 340 U.S. 147, 154 (1950) (Douglas, J., concurring).
51. *Cuno Eng'g Corp.*, 314 U.S. at 91.

"inventive genius"[52] rather than as a "result of long toil and experimentation."[53] The Court reasoned that "strict application of the test is necessary lest in the constant demand for new appliances the heavy hand of tribute be laid on each slight technological advance in the art."[54]

The Flash of Genius test was criticized for being vague and difficult to implement, and for involving subjective decisions about an inventor's state of mind.[55] It certainly made it substantially more difficult to obtain a patent.[56] Extensive criticism of perceived judicial hostility toward patents resulted in President Franklin D. Roosevelt's creation of a National Patent Planning Commission to make recommendations for improving the patent system.[57] The

52. Reckendorfer v. Faber, 92 U.S. 347, 357 (1875).
53. The Supreme Court later claimed the "Flash of Creative Genius" language was just a rhetorical embellishment, and that requirement concerned only the device itself, not the manner of invention. Graham v. John Deere Co., 383 U.S. 1, 15 n.7, 16 n.8 (1966). That was not, however, how the test was interpreted. *See* P.J. Federico, *Origins of Section 103*, 5 APLA Q.J. 87, 97 n.5 (1977) (noting the test led to a higher standard of invention in the lower courts). In *Atlantic & Pacific Tea Co. v. Supermarket Equipment Corp.*, 340 U.S. 147 (1950), another case cited for the proposition that the Court had adopted stricter patentability criteria, the majority did not consider the question of inventiveness, but in his concurring opinion Justice Douglas reiterated the concept of "inventive genius": "It is not enough that an article is new and useful. The Constitution never sanctioned the patenting of gadgets. Patents serve a higher end—the advancement of science. An invention need not be as startling as an atomic bomb to be patentable. But it has to be of such quality and distinction that that masters of the scientific field in which it falls will recognize it as an advance." *Id.*
54. *Cuno Eng'g Corp.*, 314 U.S. at 92.
55. As a commentator at the time noted, "the standard of patentable invention represented by [the Flash of Genius doctrine] is apparently based upon the nature of the mental processes of the patentee-inventor by which he achieved the advancement in the art claimed in his patent, rather than solely upon the objective nature of the advancement itself." Comment, *The "Flash of Genius" Standard of Patentable Invention*, 13 FORDHAM L. REV. 84, 87 (1944). *See* Note, *Patent Law—"Flash of Genius" Test for Invention Rejected*, 5 DEPAUL L. REV. 144, 146 (1955); Stephen G. Kalinchak, *Obviousness and the Doctrine of Equivalents in Patent Law: Striving for Objective Criteria*, 43 CATH. U. L. REV. 577, 586 (1994); *see also*, Note, *The Standard of Patentability—Judicial Interpretation of Section 103 of the Patent Act Source*, 63 COLUM. L. REV. 306, 306 (1963) [hereinafter *The Standard of Patentability*] (criticizing the standard).
56. Supreme Court Justice Robert Jackson noted in a dissent that "the only patent that is valid is one which this Court has not been able to get its hands on." Jungersen v. Ostby & Barton Co., 335 U.S. 560, 572 (1949) (Jackson, J., dissenting).
57. *See* William Jarratt, *U.S. National Patent Planning Commission*, 153 NATURE 12 (1944); *see also* REPORT OF THE NATIONAL PATENT PLANNING COMMISSION, NATIONAL PATENT PLANNING COMMISSION, at 6, 10 (1943).

Commission's report recommended that Congress adopt a more objective and certain standard of obviousness.[58] A decade later, Congress did.[59]

C. The Nonobviousness Inquiry

The Patent Act of 1952 established the modern patentability framework.[60] Among other changes to substantive patent law,[61] "the central thrust of the 1952 Act removed 'unmeasurable' inquiries into 'inventiveness' and instead supplied the nonobviousness requirement of Section 103."[62] Section 103 states:

> A patent may not be obtained . . . if the difference between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.[63]

58. REPORT OF THE NATIONAL PATENT PLANNING COMMISSION, *supra* note 57,at 5–6. "One of the greatest technical weaknesses of the patent system is the lack of a definitive yardstick as to what is invention." *Id.* at 26. "The most serious weakness of the present patent system is the lack of a uniform test or standard for determining whether the particular contribution of an inventor merits the award of the patent grant." *Id.* at 14. "It is proposed that Congress shall declare a national standard whereby patentability of an invention shall be determined by the objective test as to its advancement of the arts and sciences." *Id.* at 26.
59. Though, Congress may not have realized what it was doing. *See* George M. Sirilla, *35 U.S.C. § 103: From* Hotchkiss *to Hand to Rich, the Obvious Patent Law Hall-of-Famers*, 32 J. MARSHALL L. REV. 437, 509–14 (1999) (discussing the legislative history of the Patent Act of 1952 and the lack of congressional awareness of, and intent for, Section 103).
60. *See The Standard of Patentability*, *supra* note 55, at 309. "[P]robably no other title incorporates the thinking of so many qualified technical men throughout the country as does this revision." L. James Harris, *Some Aspects of the Underlying Legislative Intent of the Patent Act of 1952*, 23 GEO. WASH. L. REV. 658, 661 (1955).
61. "The major changes or innovations in the title consist of incorporating a requirement for invention in § 103 and the judicial doctrine of contributory infringement in § 271." H.R. REP. NO. 1923, 82d Cong., 2d Sess. 5 (1952); S. REP. NO. 1979, 82d Cong., 2d Sess. 4 (1952).
62. CLS Bank Int'l v. Alice Corp. Pty. Ltd., 717 F.3d 1269, 1296 (Fed. Cir. 2013) (Rader, J., dissenting in part, concurring in part) (citing P.J. Federidco's Commentary on the New Patent Act, *reprinted in* 75 J. PAT. & TRADEMARK OFFICE SOC'Y 161, 177 (1993)). *See also* Dann v. Johnston, 425 U.S. 219, 225–26 (1976) (describing the shift from "an exercise of the inventive faculty" established in case law to a statutory test and stating that "it was only in 1952 that Congress, in the interest of uniformity and definiteness, articulated the requirement in a statute, framing it as a requirement of 'nonobviousness'" (internal quotation marks and footnote omitted)). The official "Revision Notes" state § 103 is meant to be the basis for "holding . . . patents invalid by the courts[] on the ground of lack of invention." S. REP. NO. 82-1979, at 18.
63. 35 U.S.C. § 103, as amended by the America Invents Act. Leahy-Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284, 286 (2011) (codified at 35 U.S.C. § 103 (2018)). The America Invents Act did not fundamentally change the nonobviousness inquiry but did

Section 103 legislatively disavowed the Flash of Genius test, codified the sprawling judicial doctrine on "invention" into a single statutory test, and restructured the standard of obviousness in relation to a person having ordinary skill in the art.[64] However, while Section 103 may be more objective and definite than the Flash of Genius test, the meanings of "obvious" and "a person having ordinary skill" were not defined, and in practice also proved "often difficult to apply."[65]

The Supreme Court first interpreted the statutory nonobviousness requirement in a trilogy of cases: *Graham v. John Deere* (1966) and its companion cases, *Calmar v. Cook Chemical* (1965) and *United States v. Adams* (1966).[66] In these cases, the Court articulated a framework for evaluating obviousness as a question of law based on the following underlying factual inquiries: (1) the scope and content of the prior art, (2) the level of ordinary skill in the prior art, (3) the differences between the claimed invention and the prior art, and (4) objective evidence of nonobviousness.[67] This framework remains applicable today. Of note, the *Graham* analysis does not explain how to evaluate the ultimate legal question of nonobviousness, beyond identifying underlying factual considerations.[68]

In 1984, the newly established United States Court of Appeals for the Federal Circuit, the only appellate-level court with jurisdiction to hear patent case appeals, devised the "teaching, suggestion, and motivation" (TSM) test for obviousness.[69] Strictly applied, this test only permits an obviousness rejection when prior art explicitly teaches, suggests or motivates a combination of existing

result in some modest changes. https://www.uspto.gov/web/offices/pac/mpep/s2158.html [https://perma.cc/TAQ7-KMCC].

64. *See* Giles S. Rich, *Principles of Patentability*, 28 GEO. WASH. U. L. REV. 393, 393–407 (1960); *see also* Chin, *supra* note 48, at 318. In *Graham*, the Supreme Court noted that "[i]t . . . seems apparent that Congress intended by the last sentence of § 103 to abolish the test it believed this Court announced in the controversial phrase 'flash of creative genius,' used in *Cuno Engineering*." *Graham*, 383 U.S. at 15.

65. Uniroyal, Inc. v. Rudkin-Wiley Corp., 837 F.2d 1044, 1050 (Fed. Cir. 1988) (noting the obviousness standard is easy to expound and "often difficult to apply").

66. Graham v. John Deere Co., 383 U.S. 1 (1966); United States v. Adams, 383 U.S. 39, 51–52 (1966); Calmar v. Cook Chem., 380 U.S. 949 (1965).

67. *Graham*, 383 U.S. at 17. With regards to the fourth category, considerations such as *commercial success* and *long felt but unsolved needs* can serve as evidence of nonobviousness in certain circumstances. *Id.*

68. *See* Joseph Miller, *Nonobviousness: Looking Back and Looking Ahead*, *in* 2 INTELLECTUAL PROPERTY AND INFORMATION WEALTH: ISSUES AND PRACTICES IN THE DIGITAL AGE: PATENTS AND TRADE SECRETS 9 (Peter K. Yu ed., 2007) ("[T]he Court did *not* indicate . . . *how* one was to go about determining obviousness (or not).").

69. *Court Jurisdiction*, U.S. CT. APPEALS FOR FED. CIR., http://www.cafc.uscourts.gov/the-court/court-jurisdiction [https://perma.cc/TE4D-GRF2].

elements into a new invention.[70] The TSM test protects against hindsight bias because it requires an objective finding in the prior art. In retrospect, it is easy for an invention to appear obvious by piecing together bits of prior art using the invention as a blueprint.[71]

In *KSR v. Teleflex* (2006), the Supreme Court upheld the *Graham* analysis but rejected the Federal Circuit's exclusive reliance on the TSM test. The Court instead endorsed a flexible approach to obviousness in light of "[t]he diversity of inventive pursuits and of modern technology."[72] Rather than approving a single definitive test, the Court identified a nonexhaustive list of rationales to support a finding of obviousness.[73] This remains the approach to obviousness today.

D. Finding PHOSITA

Determining the level of ordinary skill is critical to assessing obviousness.[74] The more sophisticated the person having ordinary skill in the art (PHOSITA, or the skilled person), the more likely a new invention is to appear obvious.

70. ACS Hosp. Sys., Inc. v. Montefiore Hosp., 732 F.2d 1572 (Fed. Cir. 1984).
71. *See In re* Fritch, 972 F.2d 1260, 1266 (Fed. Cir. 1992).
72. KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 402 (2007). "[An obviousness] analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a [PHOSITA] would employ." *Id.* at 418.
73. These post-*KSR* rationales include:

> (A) Combining prior art elements according to known methods to yield predictable results; (B) Simple substitution of one known element for another to obtain predictable results; (C) Use of known technique to improve similar devices (methods, or products) in the same way; (D) Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results; (E) 'Obvious to try'—choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; (F) Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; (G) Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

2141 Examination Guidelines for Determining Obviousness Under 35 U.S.C. 103 [R-08.2017], U.S. PAT. & TRADEMARK OFF., https://www.uspto.gov/web/offices/pac/mpep/s2141.html [http://perma.cc/EE7P-4CQ9] [hereinafter *2141 Examination Guidelines*].
74. Ruiz v. A.B. Chance Co., 234 F.3d 654, 666 (Fed. Cir. 2000); *see also* Ryko Mfg. Co., v. Nu-Star, Inc.,950 F.2d 714 718 (Fed. Cir. 1991) ("The importance of resolving the level of ordinary skill in the art lies in the necessity of maintaining objectivity in the obviousness inquiry."). The skilled person is relevant to many areas of patent law, including claim construction, best mode, definiteness, enablement, and the doctrine of equivalents. *See* Dan L. Burk & Mark A. Lemley, *Is Patent Law Technology-Specific?*, 17 BERKELEY TECH. L.J. 1155, 1186–87 (2002).

Thus, it matters a great deal whether the skilled person is a "moron in a hurry"[75] or the combined "masters of the scientific field in which an [invention] falls."[76]

The skilled person has never been precisely defined, although judicial guidance exists.[77] In *KSR*, the Supreme Court described the skilled person as "a person of ordinary creativity, not an automaton."[78] The Federal Circuit has explained the skilled person is a hypothetical person, like the reasonable person in tort law,[79] who is presumed to have known the relevant art at the time of the invention.[80] The skilled person is not a judge, amateur, person skilled in remote arts, or a set of "geniuses in the art at hand."[81] The skilled person is "one who thinks along the line of conventional wisdom in the art and is not one who undertakes to innovate."[82]

The Federal Circuit has provided a nonexhaustive list of factors to consider in determining the level of ordinary skill: (1) "type[s] of problems encountered in the art," (2) "prior art solutions to those problems," (3) "rapidity with which innovations are made," (4) "sophistication of the technology," and (5) "educational level of active workers in the field."[83] In any particular case, one or more factors may predominate, and not every factor may be relevant.[84] The

75. Morning Star Coop. Soc'y v. Express Newspapers Ltd. [1979] FSR 113 (marking the first use of the term "moron in a hurry" as a standard for trademark confusion).
76. Great Atl. & Pac. Tea Co. v. Supermarket Equip. Corp., 340 U.S. 147, 155 (1950).
77. *See* James B. Gambrell & John H. Dodge, II, *Ordinary Skill in the Art—An Enemy of the Inventor or a Friend of the People?*, *in* NONOBVIOUSNESS—THE ULTIMATE CONDITION OF PATENTABILITY 5:302 (John F. Witherspoon ed., 1980) ("[T]he Supreme Court in particular, but other courts as well, has done precious little to define the person of ordinary skill in the art.").
78. KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 421 (2007). The MPEP provides guidance on the level of ordinary skill in the art. MPEP § 2141.03. *See* John F. Duffy & Robert P. Merges, *The Story of* Graham v. John Deere Company*: Patent Law's Evolving Standard of Creativity*, *in* INTELLECTUAL PROPERTY STORIES 110 (Jane C. Ginsburg & Rochelle Cooper Dreyfuss eds., 2006) (noting that determining the appropriate level of ordinary skill for the nonobviousness standard "is one of the most important policy issues in all of patent law").
79. *See, e.g.*, Panduit Corp. v. Dennison Mfg. Co., 810 F.2d 1561, 1566 (Fed. Cir. 1987) ("[T]he decision maker confronts a ghost, i.e., 'a person having ordinary skill in the art,' not unlike the 'reasonable man' and other ghosts in the law.").
80. *2141 Examination Guidelines*, *supra* note 73.
81. Envtl. Designs Ltd. v. Union Oil Co. of Cal., 713 F.2d 693, 697 (Fed. Cir. 1983).
82. Standard Oil Co. v. Am. Cyanamid Co., 774 F.2d 448, 454 (Fed. Cir. 1985).
83. *In re* GPAC Inc., 57 F.3d 1573, 1579 (Fed. Cir. 1995).
84. *Id.*; Custom Accessories, Inc. v. Jeffrey-Allan Indus., Inc., 807 F.2d 955, 962–63 (Fed. Cir. 1986). Previously, this list of factors included the "educational level of the inventor." *Envtl. Designs, Ltd.*,713 F.2d at 696. That was until the Federal Circuit announced that, "courts never have judged patentability by what the real inventor/applicant/patentee could or would do." Kimberly-Clark Corp. v. Johnson & Johnson, 745 F.2d 1437, 1454 (Fed. Cir. 1984). Instead, "[r]eal inventors, as a class, vary in the capacities from ignorant geniuses to Nobel

skilled person standard thus varies according to the invention in question, its field of art, and researchers in the field.[85] In the case of a simple invention in a field where most innovation is created by laypersons, such as, for instance, a device to keep flies away from horses, the skilled person may be someone with little education or practical experience.[86] By contrast, where an invention is in a complex field with highly educated workers such as chemical engineering or pharmaceutical research, the skilled person may be quite sophisticated.[87] At least in Europe, the skilled person may even be a team of individuals where collaborative approaches to research are the norm.[88]

---

laureates; the courts have always applied a standard based on an imaginary work of their own devising whom they have equated with the inventor." *Id.*

85. *See, e.g.*, DyStar Textilfarben GmbH & Co. Deutschland KG, 464 F.3d 1356, 1370 (Fed. Cir. 2006). The court writes:

> If the level of skill is low, for example that of a mere dyer, as Dystar has suggested, then it may be rational to assume that such an artisan would not think to combine references absent explicit direction in a prior art reference. . . . [If] the level of skill is that of a dyeing process designer, then one can assume comfortably that such an artisan will draw ideas from chemistry and systems engineering—without being told to do so.

Daiichi Sankyo Co. v. Apotex, Inc. concerned a patent for treating ear infections by applying an antibiotic to the ear. 501 F.3d 1254, 1257 (Fed. Cir. 2007). The district court found that the skilled person "would have a medical degree, experience treating patients with ear infections, and knowledge of the pharmacology and use of antibiotics." *Id.* "This person would be . . . a pediatrician or general practitioner—those doctors who are often the 'first line of defense' in treating ear infections and who, by virtue of their medical training, possess basic pharmacological knowledge." *Id.* The Federal Circuit overturned this finding, holding that rather, a person of ordinary skill in the art was "a person engaged in developing new pharmaceuticals, formulations and treatment methods, or a specialist in ear treatments such as an otologist, otolaryngologist, or otorhinolaryngologist who also has training in pharmaceutical formulations." *Id.* Courts have employed a flexible approach to considering informal education. *See, e.g.,* Penda Corp. v. United States., 29 Fed. Cl. 533, 565 (1993). For instance, in *Bose Corp. v. JBL, Inc.*, the District Court found that keeping "up with current literature and trade magazines to keep abreast of new developments" could be the equivalent of "a bachelor of science degree in electrical engineering, physics, mechanical engineering, or possibly acoustics." 112 F. Supp. 2d 138, 155 (D. Mass. 2000).

86. *See* Graham v. Gun-Munro, No. C-99-04064 CRB, 2001 U.S. Dist. LEXIS 7110, at *19 (N.D. Cal. May 22, 2001) (holding that the skilled person had some formal education but no special training in the field of art in a case regarding fly wraps for the legs of horses).

87. *See* Imperial Chem. Indus., PLC v. Danbury Pharmacal, Inc., 777 F. Supp. 330, 371–72 (D. Del. 1991) (holding that the skilled person in the chemical industry is an organic chemist with a PhD); *see also* Envtl. Designs, Ltd. v. Union Oil Co. of Cal., 713 F.2d 693, 697 (Fed. Cir. 1983) (noting the respective chemical expert witnesses of the parties with extensive backgrounds in sulfur chemistry were skilled persons).

88. *Guidelines for Examination*, EUR. PAT. OFF., http://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_vii_3.htm [https://perma.cc/XFY3-JD8J] ("There may be instances where it is more appropriate to think in terms of a group of persons, e.g. a research or production team, rather than a single person."). *See, e.g.*, MedImmune v. Novartis Pharm. U.K., Ltd., [2012] EWCA Civ. 1234 (evaluating obviousness from the perspective of

E. Analogous Prior Art

Determining what constitutes prior art is also central to the obviousness inquiry.[89] On some level, virtually all inventions involve a combination of known elements.[90] The more prior art can be considered, the more likely an invention is to appear obvious. To be considered for the purposes of obviousness, prior art must fall within the definition for anticipatory references under Section 102 and must additionally qualify as "analogous art."[91]

Section 102 contains the requirement for novelty in an invention, and it explicitly defines prior art.[92] An extraordinarily broad amount of information qualifies as prior art, including any printed publication made available to the public prior to filing a patent application.[93] Courts have long held that inventors are charged with constructive knowledge of all prior art.[94] While no real inventor could have such knowledge,[95] the social benefits of this rule are thought to outweigh its costs.[96] Granting patents on existing inventions could prevent the

---

a "skilled team"). The "[P]atent is addressed to a team of scientists with differing backgrounds in areas such as immunology, in particular antibody structural biology, molecular biology and protein chemistry, but with a common interest in antibody engineering." *Id.* In the United States, the idea that the skilled person could be a group of individuals has been discussed in academic literature, but may not have been explicitly adopted by the courts. *See, e.g.*, Jonathan J. Darrow. *The Neglected Dimension of Patent Law's PHOSITA Standard*, 23 HARV. J.L. & TECH. 227, 244, 257 (2009). A "skilled persons" standard would seem to be appropriate given that most patents are now filed with more than one inventor. Dennis Crouch, *PHOSITA: Not a Person—People Having Ordinary Skill in the Art*, PATENTLY-O (June 7, 2018), https://patentlyo.com/patent/2018/06/phosita-not-a-person-people-having-ordinary-skill-in-the-art.html [https://perma.cc/UAK2-5NT8] (noting that most patents have multiple inventors).

89. This is the second inquiry of the *Graham* analysis described earlier.
90. *See, e.g.*, Ryko Mfg. Co. v. Nu-Star, Inc., 950 F.2d 714, 718 (Fed. Cir. 1991).
91. *In re* Bigio, 381 F.3d 1320, 1325 (Fed. Cir. 2004).
92. 35 U.S.C. § 102 (2018).
93. *Id.* § 102(a)(1); *see* MPEP § 2152 for a detailed discussion of what constitutes prior art. Almost anything in writing is prior art. "A U.S. patent on the lost wax casting technique was invalidated on the basis of Benvenuto Cellini's 16th century autobiography which makes mention of a similar technique." *See* Michael Ebert, *Superperson and the Prior Art*, 67 J. PAT. & TRADEMARK OFF. SOC'Y 657, 658 (1985).
94. In *Mast, Foos, & Co. v. Stover Manufacturing Co.*, the Supreme Court applied a presumption that the skilled person is charged with constructive knowledge of all prior art: "Having *all* these various devices before him, and *whatever* the facts may have been, he is chargeable with a knowledge of all preexisting devices." 177 U.S. 485, 493 (1900) (emphasis added) (further, "we must presume the patentee was fully informed of everything which preceded him, whether such were the actual fact or not").
95. *See, e.g.*, *In re* Wood, 599 F.2d 1032, 1036 (C.C.P.A. 1979) ("[A]n inventor could not possibly be aware of every teaching in every art.").
96. *See* Bonito Boats, Inc. v. Thunder Craft Boats, Inc., 489 U.S. 141, 147–48 (1989) (reciting that Thomas Jefferson, the "driving force behind early federal patent policy," believed that

public from using something it already had access to, and remove knowledge from the public domain.[97]

For the purposes of obviousness, prior art under Section 102 must also qualify as analogous. That is to say, the prior art must be in the field of an applicant's endeavor, or reasonably pertinent to the problem with which the applicant was concerned.[98] A real inventor would be expected to focus on this type of information. The "analogous art" rule better reflects practical conditions, and it ameliorates the harshness of the definition of prior art for novelty given that prior art references may be combined for purposes of obviousness but not novelty.[99] Consequently, for the purposes of obviousness, the skilled person is presumed to have knowledge of all prior art within the field of an invention, as well as prior art reasonably pertinent to the problem the invention solves. Restricting the universe of prior art to analogous art lowers the bar to patentability.[100]

"a grant of patent rights in an idea already disclosed to the public [i]s akin to an *ex post facto* law, 'obstruct[ing] others in the use of what they possessed before'" (quoting Letter to Isaac McPherson, *supra* note 37, at 176)); Graham v. John Deere Co., 383 U.S. 1, 5–6 (1966) (stating that granting patents on non-novel inventions would remove knowledge from the public domain).

97. *Graham*, 383 U.S. at 5–6.

98. *See, e.g.*, Wyers v. Master Lock Co., 616 F.3d 1231, 1237 (Fed. Cir. 2010) ("Two criteria are relevant in determining whether prior art is analogous: '(1) whether the art is from the same field of endeavor, regardless of the problem addressed, and (2) if the reference is not within the field of the inventor's endeavor, whether the reference still is reasonably pertinent to the particular problem with which the inventor is involved.'" (quoting Comaper Corp. v. Antec, Inc., 596 F.3d 1343, 1351 (Fed. Cir. 2010)). "Under the correct analysis, any need or problem known in the field of endeavor at the time of the invention and addressed by the patent [or application at issue] can provide a reason for combining the elements in the manner claimed." KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 420 (2007). Prior art in other fields may sometimes be considered as well. *Id.* at 417. The general question is whether it would have been "reasonable" for the skilled person to consider a piece of prior art to solve their problem. *In re* Clay, 966 F.2d 656 (Fed. Cir. 1992). To be "reasonably pertinent," prior art must "logically [] have commended itself to an inventor's attention in considering his problem." *Id.*

99. *See In re* Wood, 599 F.2d 1032, 1036 (C.C.P.A. 1979) ("The rationale behind this rule precluding rejections based on combination of teachings of references from nonanalogous arts is the realization that an inventor could not possibly be aware of every teaching in every art."). The rule "attempt[s] to more closely approximate the reality of the circumstances surrounding the making of an invention by only presuming knowledge by the inventor of prior art in the field of his endeavor and in analogous arts." *Id.*

100. *See* Margo A. Bagley, *Internet Business Model Patents: Obvious by Analogy*, 7 MICH. TELECOMM. & TECH. L. REV. 253, 270 (2001) (arguing that prior to the analogous arts test references were rarely excluded as prior art); *see also* Jacob S. Sherkow, *Negativing Invention*, 2011 BYU L. REV. 1091, 1094–95 (2011) (noting that once a relevant piece of prior art is classified as analogous, an obviousness finding is often inevitable).

The analogous art requirement was most famously conceptualized in the case of *In re Winslow*, in which the court explained a decisionmaker was to "picture the inventor as working in his shop with the prior art references—which he is presumed to know—hanging on the walls around him."[101] Or, as Judge Learned Hand presciently remarked, "the inventor must accept the position of a mythically omniscient worker in his chosen field. As the arts proliferate with prodigious fecundity, his lot is an increasingly hard one."[102]

II. MACHINE INTELLIGENCE IN THE INVENTIVE PROCESS

A. Automating and Augmenting Research

Artificial intelligence (AI), which is to say a computer able to perform tasks normally requiring human intelligence, is playing an increasingly important role in innovation.[103] For instance, IBM's flagship AI system "Watson" is being used exploratively to conduct research in drug discovery, as well as clinically to analyze the genes of cancer patients and develop treatment plans.[104] In drug discovery, Watson has already identified novel drug targets and new indications for existing drugs.[105] In doing so, Watson may be generating patentable inventions either autonomously or collaboratively with human researchers.[106] In clinical practice, Watson is also automating a once human function.[107] In fact, according to IBM, Watson can interpret a patient's entire genome and prepare a clinically actionable report in ten minutes, a task which otherwise requires

101. *In re* Winslow, 365 F.2d 1017, 1020 (C.C.P.A. 1966).
102. Merit Mfg. Co. v. Hero Mfg. Co., 185 F.2d 350, 352 (2d Cir. 1950).
103. *See*, *e.g.*, DATA SCI. ASS'N, OUTLOOK ON ARTIFICIAL INTELLIGENCE IN THE ENTERPRISE 3, 6 (2016), http://www.datascienceassn.org/sites/default/files/Outlook%20on%20Artificial%20Intelligence%20in%20the%20Enterprise%202016.pdf [hereinafter Outlook on AI] (a survey of 235 business executives conducted by the National Business Research Institute (NBRI) which found that 38 percent of enterprises were using AI technologies in 2016, and 62 percent will likely use AI technologies by 2018).
104. *IBM Watson for Drug Discovery*, IBM, https://www.ibm.com/watson/health/life-sciences/drug-discovery [https://perma.cc/DQ4D-ZKJF]; *IBM Watson for Genomics*, IBM, https://www.ibm.com/watson/health/oncology-and-genomics/genomics [https://perma.cc/8XK7-S8DN].
105. Ying Chen et al., *IBM Watson: How Cognitive Computing Can Be Applied to Big Data Challenges in Life Sciences Research*, 38 CLINICAL THERAPEUTICS 688 (2016), https://www.medicalaffairs.org/app/uploads/2018/02/Chen_2016_IBM_Watson.pdf.
106. *See generally Hal the Inventor*, *supra* note 3 (discussing the "hypothetical" example of an AI system being used in drug discovery to identify new drug targets and indications for existing drugs).
107. Kazimierz O. Wrzeszczynski et al., *Comparing Sequencing Assays and Human-Machine Analyses in Actionable Genomics for Glioblastoma*, 3 NEUROLOGY GENETICS e164 (2017), http://ng.neurology.org/content/3/4/e164 [https://perma.cc/3LGH-TKPW].

around 160 hours of work by a team of experts.[108] A recent study by IBM found that Watson's report outperformed the standard practice.[109]

Watson is largely structured as an "expert system," although Watson is not a single program or computer—the brand incorporates a variety of technologies.[110] Here, Watson will be considered a single software program in the interests of simplicity. Expert systems are one way of designing AI that solve problems in a specific domain of knowledge using logical rules derived from the knowledge of experts. These were a major focus of AI research in the 1980s.[111] Expert system-based chess-playing programs HiTech and Deep Thought defeated chess masters in 1989, paving the way for another famous IBM computer, Deep Blue, to defeat world chess champion Garry Kasparov in 1997.[112] But Deep Blue had limited utility—it was solely designed to play chess. The machine was permanently retired after defeating Kasparov.[113]

Google's leading AI system DeepMind is an example of another sort of inventive machine. DeepMind uses an artificial neural network, which essentially consists of many highly interconnected processing elements working together to solve specific problems.[114] The design of neural networks is inspired by the way the human brain processes information.[115] Like the human brain, neural networks can learn by example and from practice.[116] Examples for neural networks come in the form of data, so more data means improved performance.[117] This has led to data being described as the new oil of the twenty-first century, and the fuel for machine learning.[118] Developers may not be able to

108. *Id.*
109. *Id.*
110. *See* Richard Waters, *Artificial Intelligence: Can Watson Save IBM?*, FINANCIAL TIMES (Jan. 5, 2016), https://www.ft.com/content/dced8150-b300-11e5-8358-9a82b43f6b2f [https://perma.cc/J3N6-QMP3]; *see also* Will Knight, *IBM's Watson Is Everywhere—But What Is It?*, MIT TECH. REV, (Oct. 27, 2016), https://www.technologyreview.com/s/602744/ibms-watson-is-everywhere-but-what-is-it [http://perma.cc/YK3Q-HRQB].
111. STUART J. RUSSELL & PETER NORVIG, ARTIFICIAL INTELLIGENCE: A MODERN APPROACH 22–23 (2d ed. 2002) (1995).
112. *IBM's 100 Icons of Progress: Deep Blue*, IBM http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/words [https://perma.cc/7SG3-UYST].
113. *Id.*
114. KEVIN GURNEY, AN INTRODUCTION TO NEURAL NETWORKS 1–4 (1997). The first neural network was built in 1951. *See, e.g.*, RUSSELL & NORVIG, *supra* note 111.
115. *See, e.g.*, Volodymyr Mnih et al., *Human-Level Control Through Deep Reinforcement Learning*, 518 NATURE 529, 529–33 (2015).
116. *See* GURNEY, *supra* note 114, at 1–4.
117. PEDRO DOMINGOS, THE MASTER ALGORITHM: HOW THE QUEST FOR THE ULTIMATE LEARNING MACHINE WILL REMAKE OUR WORLD xi (2015).
118. *See*, *e.g.*, Michael Palmer, *Data Is the New Oil*, ANA MARKETING MAESTROS (Nov. 3, 2006).

understand exactly how a neural network processes data or generates a particular output.

In 2016, DeepMind developed an algorithm known as AlphaGo which beat a world champion of the traditional Chinese board game Go, and then the world's leading player in 2017.[119] Go was the last traditional board game at which people had been able to outperform machines.[120] AlphaGo's feat was widely lauded in the artificial intelligence community because Go is exponentially more complicated than chess.[121] Current computers cannot "solve" Go solely by using "brute force" computation to determine the optimal move to any potential configuration in advance.[122] There are more possible board configurations in Go than there are atoms in the universe.[123] Rather than being preprogrammed with a number of optimal Go moves, DeepMind used a general-purpose algorithm to interpret the game's patterns.[124] DeepMind is now working to beat human players at the popular video game *StarCraft II*.[125]

AI like DeepMind is proving itself and training by playing games, but similar techniques can be applied to other challenges requiring recognition of complex patterns, long-term planning, and decisionmaking.[126] DeepMind is already being applied to solve practical problems. For instance, it has helped decrease cooling costs at company datacenters.[127] DeepMind is working to

119. David Silver et al., *Mastering the Game of Go With Deep Neural Networks and Tree Search*, 529 NATURE 484, 484–89 (2016). In 2015, DeepMind attained "human-level performance in video games" playing a series of class Atari 2600 games. Mnih et al., *supra* note 115, at 529. *See also*, Cade Metz, https://www.wired.com/2017/05/googles-alphago-continues-dominance-second-win-china [https://perma.cc/WA9G-JUGK].
120. *See* Richard Haridy, *2017: The Year AI Beat Us at All Our Own Games*, NEW ATLAS (Dec. 26. 2017), https://newatlas.com/ai-2017-beating-humans-games/52741 [https://perma.cc/AH2Y-6FFD].
121. Silver et al, *supra* note 119.
122. *Id.*; *cf.* Cade Metz, *One Genius' Lonely Crusade to Teach a Computer Common Sense*, WIRED (Mar. 24, 2016), [hereinafter *Lonely Crusade*] https://www.wired.com/2016/03/ doug-lenat-artificial-intelligence-common-sense-engine [https://perma.cc/WN2G-5CU9] (arguing that brute force computation was part of AlphaGo's functionality).
123. 10^{170}, or thereabouts. Silver et al, *supra* note 119.
124. Silver et al, *supra* note 119.
125. Tom Simonite, *Google's AI Declares Galactic War on* StarCraft, WIRED (Aug. 9, 2017), https://www.wired.com/story/googles-ai-declares-galactic-war-on-starcraft- [http://perma.cc/3VZJ-XXJV]. Compared with Go, *StarCraft* is vastly more complex. It involves high levels of strategic thinking and acting with imperfect information. *Id.*
126. Game playing has long been a proving ground for AI, as far back as what may have been the very first AI program in 1951. *See* Jack Copeland, *A Brief History of Computing*, ALANTURING.NET (June 2000) http://www.alanturing.net/turing_archive/pages/Reference%20Articles/BriefHistofComp.html [https://perma.cc/82JN-UC93]. That program played checkers and was competitive with amateurs. *Id.*
127. *See* Simonite, *supra* note 125.

develop an algorithm to distinguish between healthy and cancerous tissues, and to evaluate eye scans to identify early signs of diseases leading to blindness.[128] The results of this research may well be patentable.

Ultimately, the developers of DeepMind hope to create Artificial General Intelligence (AGI).[129] Existing, "narrow" or specific AI (SAI) systems focus on discrete problems or work in specific domains. For instance, "Watson for Genomics" can analyze a genome and provide a treatment plan, and "Chef Watson" can develop new food recipes by combining existing ingredients. However, Watson for Genomics cannot respond to open-ended patient queries about their symptoms. Nor can Chef Watson run a kitchen. New capabilities could be added to Watson to do these things, but Watson can only solve problems it has been programmed to solve.[130] By contrast, AGI would be able to successfully perform any intellectual task a person could.

AGI could even be set to the task of self-improvement, resulting in a continuously improving system that surpasses human intelligence—what philosopher Nick Bostrom has termed Artificial SuperIntelligence (ASI).[131] Such an outcome has been referred to as the intelligence explosion or the technological singularity.[132] ASI could then innovate in all areas of technology, resulting in progress at an incomprehensible rate. As the mathematician Irving John Good wrote in 1965, "the first ultraintelligent machine is the last invention that man need ever make."[133]

---

128. Chris Baraniuk, *Google's DeepMind to Peek at NHS Eye Scans for Disease Analysis,* BBC (July 5, 2016), https://www.bbc.com/news/technology-36713308 [https://perma.cc/ WA6R-RUX3]; Chris Baraniuk, *Google DeepMind Targets NHS Head and Neck Cancer Treatment*, BBC (Aug. 31, 2016), https://www.bbc.com/news/technology-37230806 [http://perma.cc/6GAN-7EAZ].
129. *Solving Intelligence Through Research*, DEEPMIND, https://deepmind.com/research [https://perma.cc/7TC2-49B8].
130. *See*, *e.g.*, *Lonely Crusade*, *supra* note 122.
131. *See generally* NICK BOSTROM, SUPERINTELLIGENCE: PATHS, DANGERS, STRATEGIES (2014).
132. *See generally* RAY KURZWEIL, THE SINGULARITY IS NEAR: WHEN HUMANS TRANSCEND BIOLOGY (2005).
133. Irving John Good, *Speculations Concerning the First Ultraintelligent Machine*, 6 ADVANCES IN COMPUTERS 31, 33 (1965)

    > Let an ultraintelligent machine be defined as a machine that can far surpass all the intellectual activities of any man however clever. Since the design of machines is one of these intellectual activities, an ultraintelligent machine could design even better machines; there would then unquestionably be an 'intelligence explosion,' and the intelligence of man would be left far behind. . . . Thus the first ultraintelligent machine is the last invention that man need ever make . . . .

    Id. at 32–33.

Experts are divided on when, and if, AGI will be developed. Many industry leaders predict based on historical trends that AGI will occur within the next couple of decades.[134] Others believe the magnitude of the challenge has been underestimated, and that AGI may not be developed in this century.[135] In 2013, hundreds of AI experts were surveyed on their predictions for AGI development.[136] On average, participants predicted a 10 percent likelihood that AGI would exist by 2022, a 50 percent likelihood it would exist by 2040, and a 90 percent likelihood it would exist by 2075.[137] In a similar survey, 42 percent of participants predicted AGI would exist by 2030, and an additional 25 percent predicted AGI by 2050.[138] In addition, 10 percent of participants reported they believed ASI would develop within two years of AGI, and 75 percent predicted this would occur within 30 years.[139] The weight of expert opinion thus holds artificial general intelligence and superintelligence will exist this century. In the meantime, specific artificial intelligence is getting ever better at outcompeting people at specific tasks—including invention.

B. Timeline to the Creative Singularity

We are amid a transition from human to machine inventors. The following five-phase framework illustrates this transition and divides the history and future of inventive AI into several stages.

---

134. Pawel Sysiak, *When Will the First Machine Become Superintelligent?*, AI REVOLUTION, (Apr. 11, 2016), https://medium.com/ai-revolution/when-will-the-first-machine-become-superintelligent-ae5a6f128503 [https://perma.cc/7YUP-DEYM].

135. *Id.* In fairness, history also reflects some overly optimistic predictions. In 1970, Marvin Minsky, one of the most famous AI thought leaders, was quoted in *Life Magazine* as stating, "In from three to eight years we will have a machine with the general intelligence of an average human being." Brad Darrach, *Meet Shaky, the First Electronic Person*, LIFE, Nov. 20 1970, at 58B, 66, 68.

136. *See* Muller & Bostrom, *supra* note 7.

137. *Id.* Participants were asked to provide an optimistic year for AGI's development (10 percent likelihood), a realistic year (50 percent likelihood), and a pessimistic year (90 percent likelihood). The median responses were 2022 as an optimistic year, 2040 as a realistic year, and 2075 as a pessimistic year. *Id.*

138. A survey conducted at an annual AGI Conference reported that 42 percent believed AGI would exist by 2030, 25 percent by 2050, 20 percent by 2100, 10 percent after 2010, and 2 percent never. *See* JAMES BARRAT, OUR FINAL INVENTION: ARTIFICIAL INTELLIGENCE AND THE END OF THE HUMAN ERA 152 (2013). For instance, Demis Hassabis, the founder of DeepMind, believes AGI is still decades away. David Rowan, *DeepMind: Inside Google's Super-Brain*, WIRED (June 22, 2015), https://www.wired.co.uk/article/deepmind [https://perma.cc/MM6P-EU43].

139. *See* Muller & Bostrom, *supra* note 7.

Phase	Inventors	Skilled Standard	Timeframe
I	Human	Person	Past
II	Human > SAI	Augmented Person	Present
III	Human ~ SAI	Augmented Person ~ SAI	Short Term
IV	SAI ~ AGI > Human	Augmented AGI	Medium Term
V	ASI	ASI	Long Term
SAI = Specific Artificial Intelligence; AGI = Artificial General Intelligence; ASI = Artificial Superintelligence; ~ = competing; > = outcompeting			

Table 1: Evolution of Machine Invention

Previously, in Phase I, all invention was created by people. If a company wanted to solve an industrial problem, it asked a research scientist, or a team of research scientists, to solve the problem. Phase I ended when the first patent was granted for an invention created by an autonomous machine—likely 1998 or earlier.[140] It may be difficult to determine precisely when the first patent was issued for an autonomous machine invention, as there is no obligation to report the role of machines in patent applications. Still, any number of patents have likely been issued to inventions autonomously generated by machines.[141] In 1998, a patent was issued for an invention autonomously developed by a neural network-based system known as the Creativity Machine.[142]

140. Phase I might also be distinguished by the first time a machine invented anything independently of receiving a patent. However, using the first granted patent application is a better benchmark. It is an external measure of a certain threshold of creativity, and it represents the first time a computer automated the role of a patent inventor. Of course, there is a degree of subjectivity in a patent examiner determining whether an invention is new, nonobvious, and useful. What is nonobvious to one examiner may be obvious to another. *See, e.g.*, Iain M. Cockburn et al., *Are All Patent Examiners Equal? The Impact of Characteristics on Patent Statistics and Litigation Outcomes*, *in* PATENTS IN THE KNOWLEDGE-BASED ECONOMY, (Wesley M. Cohen & Steven A. Merrill eds., 2003) (describing significant interexaminer variation).
141. *See generally*, *I Think*, *supra* note 1, at 1083–91 (describing patents issued for "computational invention").
142. *Id.* at 1083–86.

Patents may have been granted on earlier machine inventions. For instance, an article published in 1983 describes experiments with an AI program known as Eurisko, in which the program "invent[ed] new kinds of three-dimensional microelectronic devices . . . novel designs and design rules have emerged."[143] Eurisko was an early, expert AI system for autonomously discovering new information.[144] It was programmed to operate according to a series of rules known as heuristics, but it was able to discover new heuristics and use these to modify its own programming.[145] To design new microchips, Eurisko was programmed with knowledge of basic microchips along with simple rules and evaluation criteria.[146] It would then combine existing chip structures together to create new designs, or mutate existing entities.[147] The new structure would then be evaluated for interest and either retained or discarded.[148] Several references suggest a patent was granted for one of Eurisko's chip designs in the mid–1980s.[149]

Although, after investigating those references for this article, the references appear to refer to a patent application filed for the chip design by Stanford University in 1980 which the University abandoned for unknown reasons in 1984.[150] Thus, a patent was never issued. Also, as with other publicly described

143. Douglas B. Lenat et al., *Heuristic Search for New Microcircuit Structures: An Application of Artificial Intelligence*, 3 AI MAG. , 17, 17 (1982).
144. Eurisko was created by Douglas Lenat as the successor to the Automated Mathematician (AM). *See generally* Douglas B. Lenat & John Seely Brown, *Why AM and EURISKO Appear to Work*, 23 AI MAG., 269, 269–94 (1983). AM was an "automatic programming system" that could modify its own computer code, relying on heuristics. *Id.* Eurisko was a subsequent iteration of the machine designed to additionally develop new heuristics and incorporate those into its function. *Id.*
145. *See* Douglas B. Lenat et al., *supra* note 143.
146. *Id.*
147. *Id.*
148. *Id.*
149. *See, e.g.*, RICHARD FORSYTH & CHRIS NAYLOR, THE HITCHHIKER'S GUIDE TO ARTIFICIAL INTELLIGENCE IBM PC BASIC VERSION 2167 (1986); *see also* MARGARET A. BODEN, THE CREATIVE MIND: MYTHS AND MECHANISMS 228 (2004).
150. U.S. provisional patent application SN 144,960, April 29, 1980. Email From Katherine Ku, Dir. of Stanford Office of Tech. Licensing, to author (Jan. 17, 2018) (on file with author). Douglas Lenat, CEO of Cycorp, Inc., who wrote Eurisko and performed the above-mentioned research, reported that this work was done "before the modern rage about patenting things . . . " and that in his opinion Eurisko had independently created a number of patentable inventions. *See* Telephone Interview With Douglas Lenat, CEO, Cycorp, Inc. (Jan. 12, 2018). He further reported that after Eurisko came up with the chip design, Professor James Gibbons at Stanford successfully built a chip based on the machine's design. *Id.* This chip was the subject of a patent application by Stanford, but the application was abandoned in 1984. U.S. provisional patent application SN 144,960, *supra*. Prior to the present investigation, Stanford had purged its paper file for the application and so no longer had records reflecting the reason for the abandonment. Email From Katherine Ku, *supra*.

instances of patent applications claiming the output of inventive machines, the patent application was filed on behalf of natural persons.[151] In this case, they were the individuals who had built a physical chip based on Eurisko's design.[152]

In the present, Phase II, machines and people are competing and cooperating at inventive activity. However, in all technological fields, human researchers are the norm and thus best represent the skilled person standard. While AI systems are inventing, it is unclear to what extent this is occurring: Inventive machine owners may not be disclosing the extent of such machines in the inventive process, due to concerns about patent eligibility or because companies generally restrict information about their organizational methods to maintain a competitive advantage. This phase will reward early adopters of inventive machines which are able to outperform human inventors at solving specific problems, and whose output can exceed the skilled person standard. In 2006, for instance, NASA recruited an autonomously inventive machine to design an antenna that flew on NASA's Space Technology 5 (ST5) mission.[153]

While there may now only be a modest amount of autonomous[154] machine invention, human inventors are being widely augmented by creative computers. For example, a person may design a new battery using a computer to perform calculations, search for information, or run simulations on new designs. The computer does not meet inventorship criteria, but it does augment the capabilities of a researcher in the same way that human assistants can help reduce an invention to practice. Depending on the industry researchers work in and the

---

Incidentally, Dr. Lenat is now continuing to develop an expert system-based AI that can use logical deduction and inference reasoning based on "common sense knowledge," as opposed to a system like Watson that recognizes patterns in very large datasets. *Id.* He also states that his current company has developed numerous patentable inventions, but that it has not filed for patent protection, because he believes that, at least with regards to software, the downside of patents providing competitors with a roadmap to copying patented technology exceeds the value of a limited term patent. *Id.*

151. *See I Think*, *supra* note 1, at 1083–91 (describing instances of "computational invention").

152. Email From Katherine Ku, *supra* note 150. Whether the individual(s) designing a chip or building a chip would qualify as inventor(s) would depend on the specific facts of the case and who "conceived" of the invention. *See generally Hal the Inventor*, *supra* note 3 (discussing standards for inventorship).

153. Gregory S. Hornby et al., *Automated Antenna Design With Evolutionary Algorithms*, AM. INST. AERONAUTICS & ASTRONAUTICS (2006), http://alglobus.net/NASAwork/papers/Space2006Antenna.pdf.

154. As the term is used here, autonomous machines are given goals to complete by users, but determine for themselves the means of completing those goals. *See* Ryan Abbott, *The Reasonable Computer: Disrupting the Paradigm of Tort Liability*, 86 GEO. WASH. L. REV. 1 (2018). For example, a user could ask a computer to design a new battery with certain characteristics, and the computer could produce such a design without further human input. In this case, the machine would be autonomously inventive and competing with human inventors.

problems they are trying to solve, researchers may rarely be unaided by computers. The more sophisticated the computer, the more it may be able to augment the worker's skills.

Phase III, in the near future, will involve increased competition and cooperation between people and machines. In certain industries, and for certain problems, inventive machines will become the norm. For example, in the pharmaceutical industry, Watson is now identifying novel drug targets and new indications for existing drugs. Soon, it may be the case that inventive machines are the primary means by which new uses for existing drugs are researched. That is a predictable outcome, given the advantage machines have over people at recognizing patterns in very large datasets. However, it may be that people still perform the majority of research related to new drug targets. Where the standard varies within a broad field like drug discovery, this can be addressed by defining fields and problems narrowly, for instance according to the subclasses currently used by the Patent Office.[155]

Perhaps twenty-five years from now—based on expert opinion—the introduction of AGI will usher in Phase IV. Recall that AGI refers to artificial intelligence that can be applied generally, as opposed to narrowly in specific fields of art, and that it has intelligence comparable to a person. AGI will compete with human inventors in every field, which makes AGI a natural substitute for the skilled person. Even with this new standard, human inventors may continue to invent—just not as much. An inventor may be a creative genius whose abilities exceed the human average, or a person of ordinary intelligence who has a groundbreaking insight.

Just as SAI outperforms people in certain fields, it will likely be the case that SAI outperforms AGI in certain circumstances. An example of this could be when screening a million compounds for pesticide function lends itself to a "brute force" computational approach. For this reason, SAI could continue to represent the level of ordinary skill in fields in which SAI is the standard, while AGI could replace the skilled person in all other fields. However, the two systems will likely be compatible. A general AI system wanting to play Go could incorporate AlphaGo into its own programming, design its own algorithm like AlphaGo, or even instruct a second computer operating AlphaGo.

AGI will change the human-machine dynamic in another way. If the machine is genuinely capable of performing any intellectual task a person could,

155. *See generally*, *Overview of the U.S. Patent Classification System (U.S.P.C.)*, U.S. PAT & TRADEMARK OFF. (2012), https://www.uspto.gov/sites/default/files/patents/resources/classification/overview.pdf.

the machine would be capable of setting goals collaboratively with a person, or even by itself. Instead of a person instructing a computer to screen a million compounds for pesticide function, a person could merely ask a computer to develop a new pesticide. For that matter, an agrochemical company like Bayer could instruct DeepMind to develop any new technology for its business, or just to improve its profitability. Such machines should not only be able to solve known problems, but also solve unknown problems.

AGI will continually improve, transforming into ASI. Ultimately, in Phase V, when AGI succeeds in developing artificial superintelligence, it will mean the end of obviousness. Everything will be obvious to a sufficiently intelligent machine.

C. Inventive and Skilled Machines

For purposes of patent law, an inventive machine should be one which generates patentable output while meeting traditional inventorship criteria.[156] Because obviousness focuses on the quality of a patent application's inventive content, it should be irrelevant whether the content comes from a person or machine, or a particular type of machine. A machine which autonomously generates patentable output, or which does so collaboratively with human inventors where the machine meets joint inventorship criteria, is inventive.

Under the present framework, inventive machines would not be the equivalent of hypothetical skilled machines, just as human inventors are not skilled persons. In fact, it should not be possible to extrapolate about the characteristics of a skilled entity from information about inventive entities. Granted, the Federal Circuit once included the "educational level of the inventor" in its early factor-based test for the skilled person.[157] However, that was only until it occurred to the Federal Circuit that:

> [C]ourts never have judged patentability by what the real inventor/applicant/patentee could or would do. Real inventors, as a class, vary in the capacities from ignorant geniuses to Nobel laureates; the courts have always applied a standard based on an

156. *See I Think*, *supra* note 1 (arguing computers which independently meet human inventorship criteria should be recognized as inventors).
157. *See e.g.*, Environmental, *supra* note 84.

> imaginary work of their own devising whom they have equated with the inventor.[158]

What then conceptually is a skilled machine? A machine that anthropomorphizes to the various descriptions courts have given for the skilled person? Such a test might focus on the way a machine is designed or how it functions. For instance, a skilled machine might be a conventional computer that operates according to fixed, logical rules, as opposed to a machine like DeepMind which can function unpredictably. However, basing a rule on how a computer functions might not work for the same reason the Flash of Genius test failed: Even leaving aside the significant logistical problem of attempting to figure out how a computer is structured or how it generates particular output, patent law should be concerned with whether a machine is generating inventive output, not what is going on inside the machine.[159] If a conventional computer and a neural network were both able to generate the same inventive output, there should be no reason to favor one over the other.

Alternately, the test could focus on a machine's capacity for creativity. For example, Microsoft Excel plays a role in a significant amount of inventive activity, but it is not innovative. It applies a known body of knowledge to solve problems with known solutions in a predictable fashion (for example, multiplying values together). However, while Excel may sometimes solve problems that a person could not easily solve without the use of technology, it lacks the ability to engage in almost any inventive activity.[160] Excel is not the equivalent of a skilled machine—it is an automaton incapable of ordinary creativity.

Watson in clinical practice may be a better analogy for a skilled worker. Watson analyzes patients' genomes and provides treatment recommendations.[161] Yet as with Excel, this activity is not innovative. The problem Watson is solving may be more complex than multiplying a series of numbers, but it has a known solution. Watson is identifying known genetic mutations from a patient's genome. Watson is then suggesting known treatments based on existing medical literature. Watson is not innovating

158. Kimberly-Clark Corp. v. Johnson & Johnson, 745 F.2d 1437, 1454 (Fed. Cir. 1984) ("[The] hypothetical person is not the inventor, but an imaginary being possessing 'ordinary skill in the art' created by Congress to provide a standard of patentability.").
159. *See I Think*, *supra* note 1 (arguing against a subjective standard for computational invention).
160. Some behaviors like correcting a rogue formula may have a functionally creative aspect, but this is a minimal amount that would not rise to the level of patent conception if performed by a person.
161. *See* Wrzeszczynski et al., *supra* note 107.

because it is being applied to solve problems with known solutions, adhering to conventional wisdom.

Unlike Excel, however, Watson could be inventive. For instance, Watson could be given unpublished clinical data on patient genetics and actual drug responses and tasked with determining whether a drug works for a genetic mutation in a way that has not yet been recognized. Traditionally, such findings have been patentable. Watson may be situationally inventive depending on the problem it is solving.

It may be difficult to identify an actual computer program now which has a "skilled" level of creativity. To the extent a computer is creative, in the right circumstances, any degree of creativity might result in inventive output. To be sure, this is similar to the skilled person. A person of ordinary skill, or almost anyone, may have an inventive insight. Characteristics can be imputed to a skilled person, but it is not possible the way the test is applied to identify an actual skilled person or to definitively say what she would have found obvious. The skilled person test is simply a theoretical device for a decisionmaker.

Assuming a useful characterization of a skilled machine, to determine that a skilled machine now represents the average worker in a field, decisionmakers would need information about the extent to which such machines are used. Obtaining this information may not be practical. Patent applicants could be asked generally about the use and prevalence of computer software in their fields, but it would be unreasonable to expect applicants to already have, or to obtain, accurate information about general industry conditions. The Patent Office, or another government agency, could attempt to proactively research the use of computers in different fields, but this would not be a workable solution. Such efforts would be costly, the Patent Office lacks expertise in this activity, and its findings would inevitably lag behind rapidly changing conditions. Ultimately, there may not be a reliable and low-cost source of information about skilled machines right now.

D. Inventive Is the New Skilled

Having inventive machines replace the skilled person may better correspond with real world conditions. Right now, there are inherent limits to the number and capabilities of human workers. The cost to train and recruit new researchers is significant, and there are a limited number of people with the ability to perform this work. By contrast, inventive machines are software programs which may be copied without additional cost.[162] Once Watson outperforms the average industry researcher, IBM may be able to simply copy Watson and have it replace most of an existing workforce. Copies of Watson could replace individual workers, or a single Watson could do the work of a large team of researchers.

Indeed, as mentioned earlier, in a non-inventive setting, Watson can interpret a patient's entire genome and prepare a clinically actionable report in ten minutes, as opposed to a team of human experts, which takes around one-hundred and sixty hours.[163] Once Watson is proven to produce better patient outcomes than the human team, it may be unethical to have people underperform a task which Watson can automate. When that occurs, Watson should not only replace the human team at its current facility—it should replace every comparable human team. Watson could similarly automate in an inventive capacity.

Thus, inventive machines change the skilled paradigm because once they become the average worker, the average worker becomes inventive. As the outputs of these inventive machines become routinized, however, they should no longer be inventive by definition. The widespread use of these machines should raise the bar for obviousness, so that these machines no longer qualify as inventive but shift to become skilled machines—machines which now represent the average worker and are no longer capable of routine invention.[164]

Regardless of the terminology, as machines continue to improve, the bar for nonobviousness should rise. To generate patentable output, it may be necessary to use an advanced machine that can outperform standard machines, or a person or machine will need to have an unusual insight that standard machines cannot easily recreate. Inventiveness might also depend on the data supplied to a machine, such that only certain data would result in inventive output. Taken to its logical extreme, and given there is no limit to how sophisticated computers can become, it may be that everything will one day be obvious to commonly used computers.

It is possible to generate reasonably low-cost and accurate information about the use of inventive machines. The Patent Office should institute a requirement for patent applicants to disclose the role of computers in the

162. ANDREAS KEMPER, VALUATION OF NETWORK EFFECTS IN SOFTWARE MARKETS: A COMPLEX NETWORKS APPROACH 37 (2010).
163. *See* Wrzeszczynski et al., *supra* note 107.
164. *See* Enzo Biochem, Inc. v. Calgene, Inc., 188 F.3d 1362, 1374 n.10 (Fed. Cir. 1999) ("In view of the rapid advances in science, we recognize that what may be unpredictable at one point in time may become predictable at a later time.").

inventive process.[165] This disclosure could be structured along the lines of current inventorship disclosure. Right now, applicants must disclose all patent inventors.[166] Failure to do so can invalidate a patent or render it unenforceable.[167] Similarly, applicants should have to disclose when a machine autonomously meets inventorship criteria.

These disclosures would only apply to an individual invention. However, the Patent Office could aggregate responses to see whether most inventors in a field (for example, a class or subclass) are human or machine. These disclosures would have a minimal burden on applicants compared to existing disclosure requirements and the numerous procedural requirements of a patent application. In addition to helping the Patent Office with determinations of nonobviousness, these disclosures would provide valuable information for purposes of attributing inventorship.[168] It might also be used to develop appropriate innovation policies in other areas.[169]

E. Skilled People Use Machines

The current standard neglects to appropriately take into account the modern importance of machines in innovation. Instead of now replacing the skilled person with the skilled machine, it would be less of a conceptual change, and administratively easier, to characterize the skilled person as an average worker facilitated by technology. Recall the factor test for the skilled person includes: (1) "type[s] of problems encountered in the art," (2) "prior art solutions to those problems," (3) "rapidity with which innovations are made," (4) "sophistication of the technology," and (5) "educational level of active workers in the field."[170] This test could be amended to include, (6) "technologies used by

---

165. It may also be beneficial for applicants to disclose the use of computers when they have been part of the inventive process but where their contributions have not risen to the level of inventorship. Ideally, a detailed disclosure should be provided: Applicants should need to disclose the specific software used and the task it performed. In most cases, this would be as simple as noting a program like Excel was used to perform calculations. However, while this information would have value for policy making, it might involve a significant burden to patent applicants.
166. Duty to Disclose Information Material to Patentability, 37 C.F.R. § 1.56 (2018), https://www.uspto.gov/web/offices/pac/mpep/s2001.html [https://perma.cc/4DE9-ZRWE].
167. *See*, *e.g.*, Advanced Magnetic Closures, Inc. v. Rome Fastener Corp., 607 F.3d 817, 829–30 (Fed. Cir. 2010) (upholding a district court decision to render a patent unenforceable on the grounds of inequitable conduct for misrepresenting inventorship).
168. *See I Think*, *supra* note 1 (advocating for acknowledging machines as inventors).
169. *See Should Robots Pay Taxes?*, *supra* note 6 (arguing the need to monitor automation for adjusting tax incentives).
170. *In re* GPAC Inc., 57 F.3d 1573, 1579 (Fed. Cir. 1995).

active workers." This would more explicitly take into account the fact that human researchers' capabilities are augmented with computers.

Moving forward in time, once the use of inventive machines is standard, instead of a skilled person being an inventive machine, the skilled person standard could incorporate the fact that technologies used by active workers includes inventive machines. In future research, the standard practice may be for a worker to ask an inventive machine to solve a problem. This could be conceptualized as the inventive machine doing the work, or the person doing the work using an inventive machine.

Granted, in some instances, using an inventive machine may require significant skill, for instance, if the machine is only able to generate a certain output by virtue of being supplied with certain data. Determining which data to provide a machine, and obtaining that data, may be a technical challenge. Also, it may be the case that significant skill is required to formulate the precise problem to put to a machine. In such instances, a person might have a claim to inventorship independent of the machine, or a claim to joint inventorship. This is analogous to collaborative human invention where one person directs another to solve a problem. Depending on details of their interaction, and who "conceived" of the invention, one person or the other may qualify as an inventor, or they may qualify as joint inventors.[171] Generally, however, directing another party to solve a problem does not qualify for inventorship.[172] Moreover, after the development of AGI, there may not be a person instructing a computer to solve a specific problem.

Whether the future standard becomes an inventive machine or a skilled person using an inventive machine, the result will be the same: The average worker will be capable of inventive activity. Replacing the skilled person with the inventive machine may be preferable doctrinally, because it emphasizes that it is the machine which is engaging in inventive activity, rather than the human worker.

The changing use of machines also suggests a change to the scope of prior art. The analogous art test was implemented because it is unrealistic to expect inventors to be familiar with anything more than the prior art in their field, and

171. "[C]onception is established when the invention is made sufficiently clear to enable one skilled in the art to reduce it to practice without the exercise of extensive experimentation or the exercise of inventive skill." Hiatt v. Ziegler & Kilgour, 179 U.S.P.Q. 757, 763 (Bd. Pat. Interferences 1973); *see also* Gunter v. Stream, 573 F.2d 77, 79 (C.C.P.A. 1978).

172. *Ex parte* Smernoff, 215 U.S.P.Q. at 547 ("[O]ne who suggests an idea of a result to be accomplished, rather than the means of accomplishing it, is not a coinventor.").

the prior art relevant to the problem they are trying to solve.[173] However, a machine is capable of accessing a virtually unlimited amount of prior art. Advances in medicine, physics, or even culinary science may be relevant to solving a problem in electrical engineering. Machine augmentation suggests that the analogous arts test should be modified or abolished once inventive machines are common, and that there should be no difference in prior art for purposes of novelty and obviousness.[174] The scope of analogous prior art has consistently expanded in patent law jurisprudence, and this would complete that expansion.[175]

F. The Evolving Standard

The skilled person standard should be amended as follows:

1) The test should now incorporate the fact that skilled persons are already augmented by machines. This could be done by adding "technologies used by active workers" as a sixth factor to the Federal Circuit's factor test for the skilled person.
2) Once inventive machines become the standard means of research in a field, the skilled person should be an inventive machine when the standard approach to research in a field or with respect to a particular problem is to use an inventive machine.
3) When and if artificial general intelligence is developed, inventive machines should become the skilled person in all areas, taking into account that artificial general intelligence may also be augmented by specific artificial intelligence.

III. A POST-SKILLED WORLD

This Part provides examples of how the Inventive Machine Standard could work in practice, such as by focusing on reproducibility or secondary factors. It then goes on to consider some of the implications of the new standard. Once the average worker is inventive, there may no longer be a need for patents to function

173. In 1966, in *Graham*, the Court recognized that "the ambit of applicable art in given fields of science has widened by disciplines unheard of a half century ago . . . . [T]hose persons granted the benefit of a patent monopoly [must] be charged with an awareness of these changed conditions." Graham v. John Deere Co., 383 U.S. 1, 19 (1966).
174. *See supra* Subpart I.E.
175. Innovative Scuba Concepts, Inc., v. Feder Indus., Inc., 819 F. Supp. 1487, 1503 (D. Colo. 1993) (discussing the expansion of analogous art); *see also, e.g.*, George. J. Meyer Mfg. Co. v. San Marino Elec. Corp., 422 F.2d 1285, 1288 (9th Cir. 1970) (discussing the expansion of analogous art).

as innovation incentives. To the extent patents accomplish other goals such as promoting commercialization and disclosure of information or validating moral rights, other mechanisms may be found to accomplish these goals with fewer costs.

A. Application

Mobil Oil Corp. v. Amoco Chemicals Corp. concerned complex technology involving compounds known as Zeolites used in various industrial applications.[176] Mobil had developed new compositions known as ZSM-5 zeolites and a process for using these zeolites as catalysts in petroleum refining to help produce certain valuable compounds. The company received patent protection for these zeolites and for the catalytic process.[177] Mobil subsequently sued Amoco, which was using zeolites as catalysts in its own refining operations, alleging patent infringement. Amoco counterclaimed seeking a declaration of noninfringement, invalidity, and unenforceability with respect to the two patents at issue. The case involved complex scientific issues. The three-week trial transcript exceeds 3300 pages, and more than 800 exhibits were admitted into evidence.

One of the issues in the case was the level of ordinary skill. An expert for Mobil testified that the skilled person would have "a bachelor's degree in chemistry or engineering and two to three years of experience."[178] An expert for Amoco argued the skilled person would have a doctorate in chemistry and several years of experience.[179] The District Court for the District of Delaware ultimately decided that the skilled person "should be someone with at least a Masters degree in chemistry or chemical engineering or its equivalent, [and] two or three years of experience working in the field."[180]

If a similar invention and subsequent fact pattern happened today, to apply the obviousness standard proposed in this Article a decisionmaker would need to: (1) determine the extent to which inventive technologies are used in the field, (2) characterize the inventive machine(s) that best represents the average worker if inventive machines are the standard, and (3) determine whether the machine(s) would find an invention obvious. The decisionmaker is a patent

176. Mobil Oil Corp. v. Amoco Chems. Corp.,779 F. Supp. 1429, 1442–43 (D. Del. 1991).
177. *Id.*
178. *Id.* at 1443.
179. *Id.*
180. *Id.*

examiner in the first instance,[181] and potentially a judge or jury in the event the validity of a patent is at issue in trial.[182] For the first step, determining the extent to which inventive technologies are used in a field, evidence from disclosures to the Patent Office could be used. That may be the best source of information for patent examiners, but evidence may also be available in the litigation context.

Assume that today most petroleum researchers are human, and that if machines are autonomously inventive in this field, it is happening on a small scale. Thus, the court would apply the skilled person standard. However, the court would now also consider "technologies used by active workers." For instance, experts might testify that the average industry researcher has access to a computer like Watson. They further testify that while Watson cannot autonomously develop a new catalyst, it can significantly assist an inventor. The computer provides a researcher with a database containing detailed information about every catalyst used not only in petroleum research, but in all fields of scientific inquiry. Once a human researcher creates a catalyst design, Watson can also test it for fitness together with a predetermined series of variations on any proposed design.

The question for the court will thus be whether the hypothetical person who holds at least a Master's degree in chemistry or chemical engineering or its equivalent, has two or three years of experience working in the field, *and is using Watson*, would find the invention obvious. It may be obvious, for instance, if experts convincingly testify that the particular catalyst at issue were very closely related to an existing catalyst used outside of the petroleum industry in ammonia synthesis, that any variation was minor, and that a computer could do all the work of determining if it were fit for purpose.[183] It might thus have been an obvious design to investigate, and it did not require undue experimentation in order to prove its effectiveness.

Now imagine the same invention and fact pattern occurring approximately ten years into the future, at which point DeepMind, together with Watson and a competing host of AI systems, have been set to the task of developing new

181. *See* U.S. PAT. & TRADEMARK OFF., *supra* note 24 (at the Patent Office, applications are initially considered by a patent examiner, and examiner decisions can be appealed to the Patent Trial and Appeal Board (PTAB)).

182. Mark A. Lemley, *Why Do Juries Decide if Patents Are Valid?* (Stanford Law Sch., Pub. Law & Legal Theory Research Paper Series, Working Paper No. 2306152, 2013), https://ssrn.com/abstract=2306152.

183. *See* Daiichi Sankyo Co. v. Matrix Labs., Ltd., 619 F.3d 1346, 1352 (Fed. Cir. 2010) (finding that a "chemist of ordinary skill would have been motivated to select and then to modify a prior art compound (e.g., a lead compound) to arrive at a claimed compound with a reasonable expectation that the new compound would have similar or improved properties compared with the old").

compounds to be used as catalysts in petroleum refining. Experts testify that the standard practice is for a person to provide data to a computer like DeepMind, specify desired criteria (for example, activity, stability, perhaps even designing around existing patents), and ask the computer to develop a new catalyst. From this interaction, the computer will produce a new design. As most research in this field is now performed by inventive machines, a machine would be the standard for judging obviousness.

The decisionmaker would then need to characterize the inventive machine(s). It could be a hypothetical machine based on general capabilities of inventive machines, or a specific computer. Using the standard of a hypothetical machine would be similar to using the skilled person test, but this test could be difficult to implement. A decisionmaker would need to reason what the machine would have found obvious, perhaps with expert guidance. It is already challenging for a person to predict what a hypothetical person would find obvious; it would be even more difficult to do so with a machine. Computers may excel at tasks people find difficult (like multiplying a thousand different numbers together), but even supercomputers struggle with visual intuition, which is mastered by most toddlers.

In contrast, using a specific computer should result in a more objective test. This computer might be the most commonly used computer in a field. For instance, if DeepMind and Watson are the two most commonly used AI systems for research on petroleum catalysts, and DeepMind accounts for 35 percent of the market while Watson accounts for 20 percent, then DeepMind could represent the standard. However, this potentially creates a problem—if DeepMind is the standard, then it would be more likely that DeepMind's own inventions would appear obvious as opposed to the inventions of another machine. This might give an unfair advantage to non-market leaders, simply because of their size.

To avoid unfairness, the test could be based on more than one specific computer. For instance, both DeepMind and Watson could be selected to represent the standard. This test could be implemented in two different ways. In the first case, if a patent application would be obvious to DeepMind or Watson, then the application would fail. In the second case, the application would have to be obvious to both DeepMind and Watson to fail. The first option would result in fewer patents being granted, with those patents presumably going mainly to disruptive inventive machines with limited market penetration, or to inventions made using specialized non-public data. The second option would permit patents where a machine is able to outperform its competitors in some material respect. The second option could continue to reward advances in inventive machines, and therefore seems preferable.

It may be that relatively few AI systems, such as DeepMind and Watson, end up dominating the research market in a field. Alternately, many different machines may each occupy a small share of the market. There is no need to limit the test to two computers. To avoid discriminating on the basis of size, all inventive machines being routinely used in a field or to solve a particular problem might be considered. However, allowing any machine to be considered could allow an underperforming machine to lower the standard, and too many machines might result in an unmanageable standard. An arbitrary cutoff may be applied based on some percentage of market share. That might still give some advantage to very small entities, but it should be a minor disparity.

After characterizing the inventive machine(s), a decisionmaker would need to determine whether the inventive machine(s) would find an invention obvious. This could broadly be accomplished in one of two ways: either with abstract knowledge of what the machines would find obvious, perhaps through expert testimony, or through querying the machines. The former would be the more practical option.[184] For example, a petroleum researcher experienced with DeepMind might be an expert, or a computer science expert in DeepMind and neural networks. This inquiry could focus on reproducibility.

Finally, a decisionmaker will have to go through a similar process if the same invention and fact pattern occurs twenty-five years from now, at which point artificial general intelligence has theoretically taken over in all fields of research. AGI should have the ability to respond directly to queries about whether it finds an invention obvious. Once AGI has taken over from the average researcher in all inventive fields, it may be widely enough available that the Patent Office could arrange to use it for obviousness queries. In the litigation context, it may be available from opposing parties. If courts cannot somehow access AGI, they may still have to rely on expert evidence.

184. Alternatively, the machine could be asked to solve the problem at question and given the relevant prior art. If the machine generates the substance of the patent, the invention would be considered obvious. However, this would require a decisionmaker to have access to the inventive machine. At the application stage, the Patent Office would need to contract with, say, Google to use DeepMind in such a fashion. For that matter, the Patent Office might use DeepMind not only to decide whether inventions are obvious, but to automate the entire patent examination process. At trial, if Google is party to a lawsuit, an opposing party might subpoena use of the computer. However, if Google is not a party, it might be unreasonable to impose on Google for access to DeepMind.

B. Reproducibility

Even if an inventive machine standard is the appropriate theoretical tool for nonobviousness, it still requires certain somewhat subjective limitations, and decisionmakers may still have difficulty with administration. Still, the new standard only needs to be slightly better than the existing standard to be an administrative success.

A test focused on reproducibility, based on the ability of the machine selected to represent the standard being able to independently reproduce the invention, offers some clear advantages over the current skilled person standard, which results in inconsistent and unpredictable outcomes.[185] Courts have "provided almost no guidance concerning either what degree of ingenuity is necessary to meet the standard or how a decisionmaker is supposed to evaluate whether the differences between the invention and prior art meet this degree."[186] This leaves decisionmakers in the unenviable position of trying to subjectively establish what another person would have found obvious. Worse, this determination is to be made in hindsight with the benefit of a patent application. On top of that, judges and juries lack scientific expertise.[187] In practice, decisionmakers may read a patent application, decide that they know

---

185. *See* FED. TRADE COMM'N, *supra* note 16 (discussing objections to the skilled person standard).
186. Mandel, *The Non-Obvious Problem*, *supra* note 19, at 64.
187. As Judge Learned Hand wrote:

> I cannot stop without calling attention to the extraordinary condition of the law which makes it possible for a man without any knowledge of even the rudiments of chemistry to pass upon such questions as these. The inordinate expense of time is the least of the resulting evils, for only a trained chemist is really capable of passing upon such facts . . . . How long we shall continue to blunder along without the aid of unpartisan and authoritative scientific assistance in the administration of justice, no one knows; but all fair persons not conventionalized by provincial legal habits of mind ought, I should think, unite to effect some such advance.

Parke-Davis & Co. v. H.K. Mulford Co., 189 F. 95, 115 (S.D.N.Y. 1911). *See also* Safety Car Heating & Lighting Co. v. Gen. Elec. Co., 155 F.2d 937, 939 (1946) ("Courts, made up of laymen as they must be, are likely either to underrate, or to overrate, the difficulties in making new and profitable discoveries in fields with which they cannot be familiar . . . ."); *see also* Doug Lichtman & Mark A. Lemley, *Rethinking Patent Law's Presumption of Validity*, 60 STAN. L. REV. 45, 67 (2007) ("District Court judges are poorly equipped to read patent documents and construe technical patent claims. Lay juries have no skill when it comes to evaluating competing testimony about the originality of a technical accomplishment.").

obviousness when they see it, and then reason backward to justify their findings.[188]

This is problematic because patents play a critical role in the development and commercialization of products, and patent holders and potential infringers should have a reasonable degree of certainty about whether patents are valid. A more determinate standard would make it more likely the Patent Office would apply a single standard consistently and result in fewer judicially invalidated patents. To the extent machine reproducibility is a more objective standard, this would seem to address many of the problems inherent in the current standard.

On the other hand, reproducibility comes with its own baggage. Decisionmakers have difficulty imagining what another person would find obvious, and it would probably be even more difficult to imagine in the abstract what a machine could reproduce. More evidence might need to be supplied in patent prosecution and during litigation, perhaps in the format of analyses performed by inventive machines, to demonstrate whether particular output was reproducible. This might also result in a greater administrative burden.

In some instances, reproducibility may be dependent on access to data. A large health insurer might be able to use Watson to find new uses for existing drugs by giving Watson access to proprietary information on its millions of members. Or, the insurer might license its data to drug discovery companies using Watson for this purpose. Without that information, another inventive computer might not able to recreate Watson's analysis.

This too is analogous to the way data is used now in patent applications: Obviousness is viewed in light of the prior art, which does not include non-public data relied upon in a patent application. The rationale here is that this rule incentivizes research to produce and analyze new data. Yet as machines become highly advanced, it is likely that the importance of proprietary data will decrease. More advanced machines may be able to do more with less.

Finally, reproducibility would require limits. For instance, a computer which generates semi-random output might eventually recreate the inventive concept of a patent application if it were given unlimited resources. However, it would be unreasonable to base a test on what a computer would reproduce given, say, 7.5 million years.[189] The precise limits that should be placed on

188. Jacobellis v. Ohio, 378 U.S. 184, 197 (1964) (Stewart, J., dissenting). This was later recognized as a failed standard. Miller v. California, 413 U.S. 15, 47–48 (1973) (Brennan, J., dissenting) (obscenity cases similarly relying on the Elephant Test).

189. This brings to mind a super intelligent artificial intelligence system, "Deep Thought," which famously, and fictionally, took 7.5 million years to arrive at the "Answer to the Ultimate Question of Life, the Universe, and Everything." DOUGLAS ADAMS, THE HITCHHIKER'S GUIDE TO THE GALAXY 180 (rev. ed. 2001) (1979). The answer was 42. *Id.* at 188.

reproducibility might depend on the field in question, and what best reflected the actual use of inventive machines in research. For instance, when asked to design a new catalyst in the petroleum industry, Watson might be given access to all prior art and publicly available data, and then given a day to generate output.

C. An Economic vs. Cognitive Standard

The skilled person standard received its share of criticism even before the arrival of inventive machines.[190] The inquiry focuses on the degree of cognitive difficulty in conceiving an invention but fails to explain what it actually means for differences to be obvious to an average worker. The approach lacks both a normative foundation and a clear application.[191]

In *Graham*, the Supreme Court's seminal opinion on nonobviousness, the Court attempted to supplement the test with more "objective" measures by looking to real-world evidence about how an invention was received in the marketplace.[192] Rather than technological features, these "secondary" considerations focus on "economic and motivational" features, such as commercial success, unexpected results, long-felt but unsolved needs, and the failure of others.[193] Since *Graham*, courts have also considered, among other

190. *See, e.g.*, Chiang, *supra* note 19, at 49 (as one commentator noted about the test as articulated by the Supreme Court in *Graham*, it gives "all the appearance of expecting a solution to appear out of thin air once the formula was followed. The lack of an articulable rule meant that determinations of obviousness took the appearance—and arguably the reality—of resting on judicial whim . . . ." (footnote omitted)); Abramowicz & Duffy, *supra* note 16, at 1598; Gregory N. Mandel, *Patently Non-Obvious: Empirical Demonstration That the Hindsight Bias Renders Patent Decisions Irrational*, 67 OHIO ST. L.J. 1391 (2006) (discussing problems with hindsight in nonobviousness inquiries); Gregory N. Mandel, *Another Missed Opportunity: The Supreme Court's Failure to Define Nonobviousness or Combat Hindsight Bias in* KSR v. Teleflex, 12 LEWIS & CLARK L. REV. 323 (2008).

191. *See* Abramowicz & Duffy, *supra* note 16, at 1603 ("[N]either *Graham* nor in subsequent cases has the Supreme Court attempted either to reconcile the inducement standard with the statutory text or to provide a general theoretical or doctrinal foundation for the inducement standard.").

192. *See* Graham v. John Deere Co., 383 U.S. 1, 17; MPEP § 2144.

193. *Graham*, 383 U.S. at 17; MPEP § 2144. Additional secondary considerations have since been proposed. *See, e.g.*, Andrew Blair-Stanek, *Increased Market Power as a New Secondary Consideration in Patent Law*, 58 AM. U. L. REV. 707 (2009) (arguing for whether an invention provides an inventor with market power); Abramowicz & Duffy, *supra* note 16, at 1656 (proposing changing commercial success to "unexpected commercial success," adding as a consideration of the "cost of the experimentation leading to the invention," and a few additional considerations).

things, patent licensing,[194] professional approval,[195] initial skepticism,[196] near-simultaneous invention,[197] and copying.[198] Today, while decisionmakers are required to consider secondary evidence when available, the importance of these factors varies significantly.[199] *Graham* endorsed the use of secondary considerations, but their precise use and relative importance have never been made clear.[200]

An existing vein of critical scholarship has advocated for adopting a more economic than cognitive nonobviousness inquiry, for example through greater reliance on secondary considerations.[201] This would reduce the need for decisionmakers to try and make sense of complex technologies, and it could reduce hindsight bias.[202]

Theoretically, in *Graham*, the Court articulated an inducement standard, which dictates that patents should only be granted to "those inventions which would not be disclosed or devised but for the inducement of a patent."[203] But in practice, the inducement standard has been largely ignored due to concerns over application.[204] For instance, few, if any, inventions would never be disclosed or devised given an unlimited time frame. Patent incentives may not increase, so

---

194. *See, e.g.*, SIBIA Neurosciences, Inc. v. Cadus Pharm. Corp., 225 F.3d 1349, 1358 (Fed. Cir. 2000).
195. *See, e.g.*, Vulcan Eng'g Co. v. Fata Aluminum, Inc., 278 F.3d 1366, 1373 (Fed. Cir. 2002).
196. *See, e.g.*, Metabolite Labs., Inc. v. Lab. Corp. of Am. Holdings, 370 F.3d 1354, 1368 (Fed. Cir. 2004).
197. *See, e.g.*, Ecolochem, Inc. v. S. Cal. Edison Co., 227 F.3d 1361, 1379 (Fed. Cir. 2000).
198. *See*, *e.g.*, *id.* at 1377. *See also* Mark A. Lemley, *Should Patent Infringement Require Proof of Copying?*, 105 MICH. L. REV. 1525, 1534–35 (2007).
199. *See* MPEP § 2144; Durie & Lemley, *supra* note 19, at 996–97.
200. *See, e.g.*, Dorothy Whelan, *A Critique of the Use of Secondary Considerations in Applying the Section 103 Nonobviousness Test for Patentability*, 28 B.C. L. REV. 357 (1987).
201. *See, e.g.*, Merges, *supra* note 19, at 19 (arguing for patentability to be based on an a priori degree of uncertainty, that "rewards one who successfully invents when the uncertainty facing her prior to the invention makes it more likely than not that the invention won't succeed" (emphasis omitted)); Chiang, *supra* note 19, at 42 (arguing for a utilitarian standard, such that "[a]n invention should receive a patent if the accrued benefits before independent invention outweigh the costs after independent invention"); Mandel, *The Non-Obvious Problem*, *supra* note 19, at 62 (arguing for nonobviousness to be based on "how probable the invention would have been for a person having ordinary skill in the art working on the problem that the invention solves"); Durie & Lemley, *supra* note 19, at 1004–07 (arguing for a greater reliance on secondary considerations); Duffy, *supra* note 19, at 343 (arguing a timing approach to determining obviousness); Devlin & Sukhatme, *supra* note 19; Abramowicz & Duffy, *supra* note 16, at 1598 (arguing for an inducement standard).
202. *Graham*, 383 U.S. at 36 ("[Secondary considerations] may also serve to 'guard against slipping into use of hindsight.'" (citation omitted)). *See also* HERBERT F. SCHWARTZ & ROBERT J. GOLDMAN, PATENT LAW AND PRACTICE 90–91 (6th ed. 2008).
203. *Graham*, 383 U.S. at 11.
204. *See* Abramowicz & Duffy, *supra* note 16, at 1594–95.

much as accelerate, invention.[205] This suggests that an inducement standard would at least need to be modified to include some threshold for the quantum of acceleration needed for patentability. Too high a threshold would fail to provide adequate innovation incentives, but too low a threshold would be similarly problematic. Just as inventions will be eventually disclosed without patents given enough time, patents on all inventions could marginally speed the disclosure of just about everything, but a trivial acceleration would not justify the costs of patents. An inducement standard would thus require a somewhat arbitrary threshold in relation to how much patents should accelerate the disclosure of information, as well as a workable test to measure acceleration.[206] To be sure, an economic test based on the inducement standard would have challenges, but it might be an improvement over the current cognitive standard.[207]

The widespread use of inventive machines may provide the impetus for an economic focus. After inventive machines become the standard way that R&D is conducted in a field, courts could increase reliance on secondary factors. For instance, patentability may depend on how costly it was to develop an invention, and the ex ante probability of success.[208] There is no reason an inventive machine cannot be thought of, functionally, as an economically motivated rational actor. The test would raise the bar to patentability in fields where the cost of invention decreases over time due to inventive machines.

D. Other Alternatives

Courts may maintain the current skilled person standard and decline to consider the use of machines in obviousness determinations. However, this means that as research is augmented and then automated by machines, the average worker will routinely generate patentable output. The dangers of such a

205. *See, e.g.*, Yoram Barzel, *Optimal Timing of Innovations*, 50 REV. ECON. & STATS. 348, 348 (1968); John F. Duffy, *Rethinking the Prospect Theory of Patents*, 71 U. CHI. L. REV. 439, 444 (2004).
206. Abramowicz & Duffy, *supra* note 16, at 1599 (proposing a “substantial period of time”).
207. *See* Abramowicz & Duffy, *supra* note 16, at 1663.
208. *Id.*

standard for patentability are well-recognized.[209] A low obviousness requirement can "stifle, rather than promote, the progress of the useful arts."[210]

Concerns already exist that the current bar to patentability is too low, and that a patent "anticommons" with excessive private property is resulting in "potential economic value . . . disappear[ing] into the 'black hole' of resource underutilization."[211] It is expensive for firms interested in making new products to determine whether patents cover a particular innovation, evaluate those patents, contact patent owners, and negotiate licenses.[212] In many cases, patent owners may not wish to license their patents, even if they are non-practicing entities that do not manufacture products themselves.[213] Firms that want to make a product may thus be unable to find and license all the rights they need to avoid infringing. Adding to this morass, most patents turn out to be invalid or not infringed in litigation.[214] Excessive patenting can thus slow innovation, destroy markets, and, in the case of patents on some essential medicines, even cost lives.[215] Failing to raise the bar to patentability once the use of inventive machines is widespread would significantly exacerbate this anticommons effect.

Instead of updating the skilled person standard, courts might determine that inventive machines are incapable of inventive activity, much as the U.S. Copyright Office has determined that nonhuman authors cannot generate copyrightable output.[216] In this case, otherwise patentable inventions might not

209. *See, e.g.*, ADAM B. JAFFE & JOSH LERNER, INNOVATION AND ITS DISCONTENTS: HOW OUR BROKEN PATENT SYSTEM IS ENDANGERING INNOVATION AND PROGRESS, AND WHAT TO DO ABOUT IT 32–35, 75, 119–23, 145–49 (2004) (criticizing the Patent Office for granting patents on obvious inventions); NATIONAL RESEARCH COUNCIL, A PATENT SYSTEM FOR THE 21ST CENTURY 87–95 (2004) (criticizing lenient nonobviousness standards); Matthew Sag & Kurt Rohde, *Patent Reform and Differential Impact*, 8 MINN. J.L. SCI. & TECH. 1, 2 (2007) ("Academics, business leaders, and government officials have all expressed concern that too many patents are issued for [obvious] inventions.").

210. KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 427 (2007).

211. James M. Buchanan & Yong J. Yoon, *Symmetric Tragedies: Commons and Anticommons*, 43 J.L. & ECON. 1, 2; *accord* DAN L. BURK & MARK A. LEMLEY, THE PATENT CRISIS AND HOW THE COURTS CAN SOLVE IT (2009) (arguing for a heightened bar to patentability).

212. *See generally* Mark A. Lemley, *Ignoring Patents*, 2008 MICH. ST. L. REV. 19, 25–26 (2008) (describing various costs associated with innovation in patent heavy industries).

213. *See* David L. Schwartz & Jay P. Kesan, *Analyzing the Role of Non-Practicing Entities in the Patent System*, 99 CORNELL L. REV. 425 (2014).

214. *See* Mark A. Lemley & Carl Shapiro, *Probabilistic Patents*, 19 J. ECON. PERSP. 75, 80 (2005).

215. *See* Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition From Marx to Markets*, 111 HARV. L. REV. 621 (1998); *see also* MICHAEL HELLER, THE GRIDLOCK ECONOMY: HOW TOO MUCH OWNERSHIP WRECKS MARKETS, STOPS INNOVATION AND COSTS LIVES (2008); *see also* Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698 (1998).

216. This has been a policy of the Copyright Office since at least 1984. *See* U.S. COPYRIGHT OFFICE, COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES § 306 (3d ed. 2014). The

be eligible for patent protection, unless provisions were made for the inventor to be the first person to recognize the machine output as patentable. However, this would not be a desirable outcome. As I have argued elsewhere, providing intellectual property protection for computer-generated inventions would incentivize the development of inventive machines, which would ultimately result in additional invention.[217] This is most consistent with the constitutional rationale for patent protection "[t]o promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries."[218]

E. Incentives Without Patents?

Today, there are strong incentives to develop inventive machines. Inventions by these machines have value independent of intellectual property protection, but they should also be eligible for patent protection. People may apply as inventors for recognizing the inventive nature of a machine's output,[219] or more ambitiously, inventive machines may be recognized as inventors, resulting in stronger and fairer incentives.

Once inventive machines set the baseline for patentability, standard inventive machines, as well as people, should have difficulty obtaining patents. It is widely thought that setting a nonobviousness standard too high would reduce the incentives for innovators to invent and disclose. Yet once inventive machines are normal, there should be less need for patent incentives.[220] Once the

---

Compendium of U.S. Copyright Office Practices elaborates on the "human authorship" requirement by stating: "The term 'authorship' implies that, for a work to be copyrightable, it must owe its origin to a human being." *Id.* It further elaborates on the phrase "[w]orks not originated by a human author" by stating: "In order to be entitled to copyright registration, a work must be the product of human authorship. Works produced by mechanical processes or random selection without any contribution by a human author are not registrable." *Id.* § 503.03(a).

217. *See generally I Think*, *supra* note 1.

218. U.S. CONST. art. I, § 8, cl. 8.

219. Conception requires contemporaneous recognition and appreciation of the invention. *See* Invitrogen Corp. v. Clontech Labs., Inc., 429 F.3d 1052, 1064 (Fed. Cir. 2005) (noting that the inventor must have actually made the invention and understood the invention to have the features that comprise the inventive subject matter at issue); *see also, e.g.*, Silvestri v. Grant, 496 F.2d 593, 597 (C.C.P.A. 1974) ("[A]n accidental and unappreciated duplication of an invention does not defeat the patent right of one who, though later in time, was the first to recognize that which constitutes the inventive subject matter.").

220. *See generally*, Mark A. Lemley, *IP in a World Without Scarcity* (Stanford Public Law, Working Paper No. 2413974, 2014), http://dx.doi.org/10.2139/ssrn.2413974 (arguing new technologies that reduce costs will weaken the case for IP).

average worker is inventive, inventions will "occur in the ordinary course."[221] Machine inventions will be self-sustaining. In addition, the heightened bar might result in a technological arms race to create ever more intelligent computers capable of outdoing the standard. That would be a desirable outcome in terms of incentivizing innovation.

Even after the widespread use of inventive machines, patents may still be desirable. For instance, patents may be needed in the biotechnology and pharmaceutical industries to commercialize new technologies. The biopharma industry claims that new drug approvals cost around 2.2 billion dollars and take an average of eight years.[222] This cost is largely due to resource intensive clinical trials required to prove safety and efficacy. Once a drug is approved, it is often relatively easy for another company to recreate the approved drug. Patents thus incentivize the necessary levels of investment to commercialize a product given that patent holders can charge monopoly prices for their approved products during the term of a patent.

Yet patents are not the only means of promoting product commercialization. Newly approved drugs and biologics, for example, receive a period of market exclusivity during which time no other party can sell a generic or biosimilar version of the product. Newly approved biologics, for instance, receive a twelve-year exclusivity period in the United States. Because of the length of time it takes to get a new biologic approved, the market exclusivity period may exceed the term of any patent an originator company has on its product. A heightened bar to patentability may lead to greater reliance on alternative forms of intellectual property protection such as market exclusivity, prizes, grants, or tax incentives.[223]

With regards to disclosure, without the ability to receive patent protection, owners of inventive machines may choose not to disclose their discoveries and rely on trade secret protection. However, with an accelerated rate of technological progress, intellectual property holders would run a significant risk that their inventions would be independently recreated by inventive machines.

Depending on the type of innovation, industry, and competitive landscape, business ventures may be successful without patents, and patent protection is

221. KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 402 (2007).
222. Joseph A. DiMasi, Henry G. Grabowski, & Ronald W. Hansen, *Innovation in the Pharmaceutical Industry: New Estimates of R&D Costs*, 47 J. OF HEALTH ECON. 20–33 (2016).
223. *See generally* Daniel J. Hemel & Lisa Larrimore Ouellette, *Beyond the Patents-Prizes Debate*, 92 TEX. L. REV. 303 (2013) (describing various nontraditional intellectual property incentives).

not sought for all potentially patentable inventions.[224] In fact, "few industries consider patents essential."[225] For instance, patents are often considered a critical part of biotechnology corporate strategy, but often ignored in the software industry.[226] On the whole, a relatively small percentage of firms patent, even among firms conducting R&D.[227] Most companies do not consider patents crucial to business success.[228] Other types of intellectual property such as trademark, copyright, and trade secret protection, combined with "alternative" mechanisms such as first mover advantage and design complexity may protect innovation even in the absence of patents.[229]

F. A Changing Innovation Landscape

Inventive machines may result in further consolidation of wealth and intellectual property in the hands of large corporations like Google and IBM. Large enterprises may be the most likely developers of inventive machines due to their high development costs.[230] A counterbalance to additional wealth disparity could be broad societal gains. The public would stand to gain access to a tremendous amount of innovation—innovation which might be significantly delayed or never come about without inventive machines. In fact, concerns about industry consolidation are another basis for revising the obviousness inquiry. The widespread use of inventive machines may be inevitable, but raising the bar to patentability would make it so that inventions which would

224. BRONWYN HALL ET AL., INTELLECTUAL PROPERTY OFFICE, THE USE OF ALTERNATIVES TO PATENTS AND LIMITS TO INCENTIVES, 2 (2012), http://webarchive.nationalarchives.gov.uk/20140603121456/http://www.ipo.gov.uk/ipresearch-patalternative.pdf; *see also*, Rochelle Cooper Dreyfuss, *Does IP Need IP? Accommodating Intellectual Production Outside the Intellectual Property Paradigm*, 31 CARDOZO L. REV. 1437, 1439 (2010); *see also* David Fagundes, *Talk Derby to Me: Intellectual Property Norms Governing Roller Derby Pseudonyms*, 90 TEX. L. REV. 1094, 1146 (2012) (describing norm-based protections that function effectively in the absence of traditional IP). Patent holders are only successful in about a quarter of cases that are litigated to a final disposition and appealed. Paul M. Janicke & LiLan Ren, *Who Wins Patent Infringement Cases?*, 34 AIPLA Q.J. 1, 8 (2006). Fewer than two percent of patents are ever litigated, and only about 0.1 percent go to trial. Lemley & Shapiro, *supra* note 214, at 79. In cases where the validity of a patent is challenged, about half of the time the patent is invalidated. Allison & Lemley, *supra* note 20, at 205 (1998).

225. Merges, *supra* note 19, at 19.

226. *See generally*, Lemley & Shapiro, *supra* note 214.

227. *Id.*

228. *Id.*

229. *Id.*

230. *See* Jamie Carter, *The Most Powerful Supercomputers in the World—and What They Do*, TECHRADAR (Dec. 13, 2014), http://www.techradar.com/us/news/computing/the-most-powerfulsupercomputers-in-the-world-and-what-they-do-1276865 (noting that most advanced computer systems are owned by governments and large businesses).

naturally occur would be less likely to receive protection. To the extent market abuses such as price gouging and supply shortages are a concern, protections are, at least theoretically, built into patent law to protect consumers against such problems.[231] For example, the government could exercise its march in rights or issue compulsory licenses.[232]

Inventive machines may ultimately automate knowledge work and render human researchers redundant. While past technological advances have resulted in increased rather than decreased employment, the technological advances of the near future may be different.[233] There will be fewer limits to what machines will be able to do, and greater access to machines. Automation should generate innovation with net societal gains, but it may also contribute to unemployment, financial disparities, and decreased social mobility.[234] It is important that policymakers act to ensure that automation benefits everyone, for instance by investing in retraining and social benefits for workers rendered technologically unemployed.[235] Ultimately, patent law alone will not determine whether automation occurs. Even without the ability to receive patent protection, once inventive machines are significantly more efficient than human researchers, they will replace people.

CONCLUSION

> Prediction is very difficult, especially about the future.[236]

In the past, patent law has reacted slowly to technological change. For instance, it was not until 2013 that the Supreme Court decided human genes should be unpatentable.[237] By then, the Patent Office had been granting patents on human genes for decades,[238] and more than 50,000 gene-related patents had been issued.[239]

231. *See Balancing Access*, *supra* note 27 (discussing patent law protections against practices including "evergreening").
232. *See id.* at 345 (explaining India's issuance of a compulsory license).
233. *See Should Robots Pay Taxes?*, *supra* note 6; *see supra* Part I.
234. *Id.*
235. *Id.*
236. ARTHUR K. ELLIS, TEACHING AND LEARNING ELEMENTARY SOCIAL STUDIES 56, (1970) (quoting physicist Niels Bohr).
237. Ass'n for Molecular Pathology v. Myriad Genetics, Inc., 133 S. Ct. 2107 (2013).
238. *See, e.g.*, U.S. Patent No. 4,447,538 (filed Feb. 5, 1982) (a patent issued in 1984 which claims the human *Chorionic Somatomammotropin* gene).
239. Robert Cook-Deegan & Christopher Heaney, *Patents in Genomics and Human Genetics*, 11 ANN. REV. OF GENOMICS & HUM. GENETICS 383, 384 (2010) ("In April 2009, the U.S. Patent

Eminent technologists now predict that artificial intelligence is going to revolutionize the way innovation occurs in the near to medium term. Much of what we know about intellectual property law, while it might not be wrong, has not been adapted to where we are headed. The principles that guide patent law need to be, if not rethought, then at least retooled in respect of inventive machines. We should be asking what our goals are for these new technologies, what we want our world to look like, and how the law can help make it so.

and Trademark Office (USPTO) granted the 50,000th U.S. patent that entered the DNA Patent Database at Georgetown University. That database includes patents that make claims mentioning terms specific to nucleic acids (e.g., DNA, RNA, nucleotide, plasmid, etc.).").

ARTIFICIAL INTELLIGENCE, BIG DATA AND INTELLECTUAL PROPERTY: PROTECTING COMPUTER-GENERATED WORKS IN THE UNITED KINGDOM

RYAN ABBOTT*

Abstract: Big data and its use by artificial intelligence (AI) is changing the way intellectual property is developed and granted. For decades, machines have been autonomously generating works which have traditionally been eligible for copyright and patent protection. Now, the growing sophistication of AI and the prevalence of big data is positioned to transform computer-generated works (CGWs) into major contributors to the creative and inventive economies. However, intellectual property law is poorly prepared for this eventuality. The UK is one of the few nations, and perhaps the only EU member state, to explicitly provide copyright protection for CGWs. It is silent on patent protection for CGWs.

This chapter makes several contributions to the literature. First, it provides an up-to-date review of UK, EU and international law. Second, it argues that patentability of CGWs is a matter of first impression in the UK, but that CGWs should be eligible for patent protection as a matter of policy. Finally, it argues that the definition of CGWs should be amended to reflect the fact that a computer can be an author or inventor in a joint work with a person.

Keywords: computer-generated works, artificial intelligence law, big data and intellectual property, international law, patents

I. INTRODUCTION

Big data and its use by artificial intelligence (AI) is changing the way intellectual property is developed and granted. For decades, machines have been autonomously generating works which have traditionally been eligible for copyright and patent protection.[1] For instance, in the US, the first "computer-generated work" (CGW) was submitted for copyright registration prior to 1965. The US Patent and Trademark Office (USPTO) has granted patents for inventions autonomously generated by computers as early as 1998. Terms such as "computers" and "machines" are used in this chapter interchangeably to refer to computer programs or software rather than to physical devices or hardware. As AI continues to grow exponentially more sophisticated and powerful, and the amount of data available to these machines keeps pace, CGWs should become a major contributor to the creative and inventive economies.[2]

This chapter considers the phenomenon of CGWs from a UK, EU and international law perspective. There is little law on the subject. UK law explicitly provides for copyright protection of CGWs, and in this respect, it is an outlier in the EU and internationally. However, UK law is silent on patent protection. No UK, EU or international law explicitly prohibits protection for

* Professor of Law and Health Sciences, University of Surrey, School of Law and Adjunct Assistant Professor of Medicine at the David Geffen School of Medicine at University of California, Los Angeles. This is a draft chapter. The final version will be available in *Research Handbook on Intellectual Property and Digital Technologies* edited by Tanya Aplin, forthcoming, Edward Elgar Publishing Ltd.

CGWs, but rarely are such works explicitly protected. Legal instruments and judicial language related to both copyright and patents frequently refer to authors and inventors as natural persons, or restrict authorship or inventorship to natural persons, but this is most likely in response to the prospect of corporate authorship and inventorship. Such language does not appear to be the result of seriously considering CGWs and should not prohibit IPRs as a matter of policy.

This chapter begins by describing the phenomenon of CGWs and then reviewing the relevant law. It seeks to resolve the following questions: Are computers autonomously creating or inventing or merely aiding human authors and inventors? How will inventive machines alter research and development? Can a CGW receive copyright or patent protection? Can a person qualify as an author or inventor for a machine's output? Who would own IPRs associated with a CGW? These and other questions can be answered by referring to the fundamental policy rationales for IPRs, and by analogy to instances of human authorship and invention.

The chapter argues that patentability of CGWs is a matter of first impression in the UK, but that CGWs should be eligible for patent protection. This would incentivize the development of inventive machines, which will ultimately result in more innovation. Acknowledging machines as inventors would also safeguard moral rights, because it would prevent people from receiving undeserved acknowledgement.

The chapter also proposes that the standard for CGWs should be amended—for copyright as well as patent. Rather than treating a CGW as a work "generated by a computer in circumstances such that there is no human author of the work", a CGW should be a work "generated by a computer in circumstances such that the computer, if a natural person, would be an author." Similarly, for patents, CGW should be a work "generated by a computer in circumstances such that the computer, if a natural person, would be an inventor." This would take into account the fact that people and machines often work collaboratively, and that even with the involvement of a person a machine can contribute as an author or inventor in its own right.

Finally, this chapter argues there is a need for an internationally harmonized approach to CGWs. Most jurisdictions in the EU, and worldwide, have yet to decide how to regulate CGWs. Failure to internationally harmonize may disadvantage countries which permit IPRs for CGWs, and advantage those which do not.

II. Creative Computers and Inventive Machines

The Growing Sophistication of AI

Much has been written about the increasing capacity of AI to engage in knowledge-work. Indeed, hardly a day goes by without a news article describing some new feat achieved by AI, whether it is IBM's AI system *DeepBlue* beating Garry Kasparov at Chess, IBM's *Watson* winning a game of Jeopardy, or Google's *DeepMind* defeating a Go world champion in 2016. DeepMind's Go victory was unexpected at the time because of the sheer complexity of the game, which has more potential Go board configurations than there are atoms in the Universe. AI systems are playing games to demonstrate their capabilities and to train, but they are also being applied to solve practical problems. Watson, for example, is being used to find new uses for existing drugs—an activity that has traditionally been fertile grounds for generating patentable inventions.

Computer knowledge-work can be thought of on a spectrum. On the one end, computers may function as simple tools that assist human authors and inventors, much the way that a pen or a wrench can help someone to write or invent. Works generated in this fashion have been referred to as "works created using a computer", and likely account for the vast majority of human-machine collaboration. While it could not be seriously argued that Microsoft Word should be a co-author of this chapter, it did contribute to the chapter's creation. At times, Word corrects spelling, automatically formats, and even suggests the use of certain words.

The term "intermediate works" has been used to refer to more substantive contributions made by computers to creative works where a person qualifies as an author or inventor. It may be difficult to precisely distinguish between an intermediate work and a work created using a computer. Word probably could not contribute to an intermediate work, but a variety of publicly available software programs can. For instance, "Band-in-a-Box" allows a user to choose chords and styles, and the program then automatically generates a "complete professional-quality arrangement of piano, bass, drums, guitar, and strings or horns."[3] Other programs can make similarly substantive contributions to different types of creative works, such as novels and films. In some instances of intermediate works, it may be the case that the computer would qualify as a joint author or inventor, if it were a natural person.

At the other end of the spectrum, computers generate works under circumstances in which no human author or inventor can be identified. These are often referred to as CGWs or "works created by a computer". While not widely appreciated, computers have been creating CGWs for decades. As an interesting example of the interplay between copyright and patent, in 2003, technologist Raymond Kurzweil, now a Director of Engineering at Google, was granted a patent on a computer program that could autonomously generate creative writings—the "Cybernetic Poet." Incidentally, Mr. Kurzweil now predicts that machines will have human levels of intelligence in about a decade.

The argument has been made that a human author or inventor exists for any CGW, in the sense that, "behind every good robot is a good person."[4] It is true that a programmer (or *many* programmers and developers) has to create computer software, and in some cases it may make sense to impute authorship or inventorship to a programmer—particularly if a programmer develops an algorithm specifically to solve a particular problem or to generate a particular output. In these cases a programmer might have a significant contribution to a machine's speicifc output. However, it may also be the case that a programmer creates an algorithm with no expectation or knowledge of the problems it will go on to solve. Some AI systems such as neural networks can behave unpredictably, such that their original programmers may not understand precisely how they function.[5] Some computer systems, such as those based on genetic programming, may even be able to alter their own code. By analogy to human inventorship, an inventor's teachers, mentors and even parents do not qualify as inventors on their patents, at least, not without directly contributing to the conception of a specific invention.

Attributing authorship or inventorship to a computer *user*, rather than a programmer, is also problematic. It may sometimes be the case that a user makes a significant contribution to a computer's output, or that formulating instructions to a computer requires significant skill. However, it may also be the case that a user simply asks a computer to solve a problem, and the computer proceeds to independently generate an answer. In the future, it may even be the case that the computer is able to identify that its output is eligible for copyright or patent protection. In such cases, it seems difficult to argue that the user is an author or inventor. Again, by analogy to human works, simply instructing another person to solve a problem does not *usually* qualify for authorship or inventorship.

Thus, in at least some instances, computers are generating works traditional entitled to copyright and patent protection under circumstances in which no natural person qualifies as an author or inventor according to traditional criteria. In practice, it may be difficult to distinguish between works created using a computer, intermediate works, and works created by a computer. However, this is not unlike making sense of human authorship and inventorship for joint works where individuals make diverse contributions.

Where's the CGW?

Given these technological advances, one would be forgiven for asking—where are the CGWs? Why are there not routinely lawsuits over CGWs? How have countries managed without legal standards for CGWs?

It may be that the creative AI revolution has yet to arrive. CGWs may be few and far between, or lack commercial value. When Scott French programmed a computer to write a novel in the style of a famous author in 1993, the resulting work was described by one critic as, "a mitigated disaster".[6] Likewise, with regard to inventions, computers may rarely be inventing, or these outputs may lack significant utility.

It may also be that computers *are* creating CGWs, but that this is not being disclosed. There are good reasons to think this may be the case. In the US, for example, CGWs are not entitled to copyright protection. In 1965, the US Copyright Office reported it received several applications for CGWs. Given the exponential improvements in computer science, one would thus expect a similarly exponential increase in CGWs submitted for copyright protection from 1965 until the present. However, at least as early as 1973, the US Copyright Office elected to deny protection for CGWs.[7] As a result, anyone in possession of a potentially valuable CGW would disqualify protection for the work by revealing its origins. A computer user wishing to obtain protection for a CGW may thus end up identifying himself or herself as the author. Similarly, in the UK, it is not clear that CGWs are entitled to patent protection. Computer users may thus elect to identify themselves as inventors for CGWs. Indeed, some of the earliest applicants for patents on CGWs were advised by their attorneys to report themselves as inventors.[8]

Failing to disclose the machine's role in a CGW may also seem an appealing option because it is unlikely to be challenged. For instance, in the UK, CGWs are protected by copyright without registration, and the UK Intellectual Property Office (IPO) will not dispute a patent applicant's reported inventorship unless this is challenged by a third-party. The issue of authorship or inventorship of a CGW may not arise until litigation, and even that is unlikely. When human authors and inventors have a disagreement about relative contributions, there will generally be one or more parties with an adverse legal interest. However, if a user takes credit for a computer's invention, the computer is not in a position to protest. A legal dispute will probably only occur in cases where an alleged infringing party wants to dispute copyright or patent protection can subsist in a CGW, and somehow becomes aware that a computer was involved in generating the work.

This situation with respect to CGWs is a problematic state of affairs. It is important that authorship and inventorship be accurately attributed, both to optimize the use of copyright and patents as economic incentives, and to preserve the moral rights of natural persons. Establishing an author or inventor's identity is important because whether the work qualifies for protection in the UK may depend on the author's national status. It also identifies the first owner of copyright or patent, may base the term of copyright protection on the author's death, and determines whether there are moral and rental rights belonging to an author. In whatever manner nations elect to protect CGWs, including by providing no protection, appropriate identification of the origin of CGWs is necessary for IPRs to function effectively as economic rights. Even with regard to moral rights, failure to designate a computer as an author or inventor may result in individuals taking credit for works they have not personally generated. This may undermine the value of human authorship and inventorship.

Determining computer authorship and inventorship may be a complex endeavor. However, that is already the case with natural persons. For instance, despite the romantic conception of inventors as lone prodigies tinkering in their garages and experiencing flashes of genius, the vast majority of invention comes from industry and academic work where multi-person collaborations are the norm. Inventorship disputes are becoming more common,[9] and determining inventorship in collaborative work is "one of the muddiest concepts in the muddy metaphysics of the patent law".[10]

III. Legal Standards

Intellectual property in the UK is primarily governed at the national level, subject to compliance with certain EU requirements and international treaties.

United Kingdom Standards for Computer-Generated Works

The Copyright, Designs and Patents Act 1998 ("CDPA") is the primary legislation for copyright law.[11] Copyright is an intellectual property right which subsists in certain creative works such as books, music and movies. It gives its owner the exclusive right to exploit the underlying subject matter for a fixed number of years, generally 70 years plus the life of the author, subject to certain exceptions such as fair dealing. Generally, the author of a work is the person who creates it, and the author is the default copyright owner. A notable exception is that an employer will be the default owner if a work is "made by" an employee in the course of employment. In some instances, an "author" can be a body incorporated in the UK, such as a limited company.[12] Special authorship rules apply to "entrepreneurial" or "media" works—sound recordings, films, broadcasts and typographical works—that are produced rather than created, whereby legal entities are accepted as authors.

The CDPA makes special provision for CGWs with different rules for authorship and copyright duration. These works are defined as those "generated by a computer in circumstances such that there is no human author of the work[s]." CDPA §178. For these works, the CDPA provides that, "[i]n the case of a literary, dramatic, musical or artistic work which is computer-generated, the author shall be taken to be the person by whom the arrangement necessary for the creation of the work are undertaken." CDPA §9(3). Of note, this protection only extends to literary, dramatic, musical and artistic works and not to media works, although a similar system to §9(3) also applies with regard to design rights.[13] For CGWs, the term of the copyright is fifty years from the end of the calendar year in which the work was made.[14]

At least two cases considered CGWs under the Copyright Act 1956, the statutory regime prior to the CDPA.[15] This statute had no provisions for CGWs.[16] In *Express Newspapers plc v Liverpool Daily Post & Echo* [1985] FSR 306, the plaintiff newspaper *Daily Express* conducted a 'Millionaire of the Month' competition. It distributed cards with a five-letter code, and the public could check these cards against a daily newspaper grid, generated by a computer, to see if they won a prize. The defendant newspaper copied these grids, and was subsequently sued for copyright infringement. One argument advanced by the defendant was that because the grids were produced with the aid of a computer, they had no human author and thus could not be protected by copyright. Whitford J rejected this argument, stating, "[t]he computer was no more than the tool by which the varying grids of five-letter sequences were produced to the instructions, via the computer programs, of [the programmer]. It is as unrealistic [to suggest the programmer was not the author] as it would be to suggest that, if you write your work with a pen, it is the pen which is the author of the work rather than the person who drives the pen." *Id*. Whitford J also noted "that a great deal of skill and indeed, a good deal of labour went into the production of the grid and the two separate seqences of five letters". *Id*.

Prior to this case, in 1977, Whitford J had chaired the "Whitford Report" which found of computer-generated works, "the correct approach is to look on the computer as a mere tool in much the same way as a slide rule or even, in a simple sense, a paint brush. A very sophisticated tool it may be, with considerable powers to extend man's capabilities to create new works, but a tool nevertheless."[17] The Whitford Report concluded that both the computer programmer and the person who originated data to provide the computer should be authors of any resultant CGW. In response to the Whitford Report, the Government issued the *Green Paper* report. Among other things, this report argued that the computer user, as potentially distinct from the programmer and originator of data, should generally also be an author.[18] In 1986, the Government published a White Paper, *Intellectual Property and Innovation*, which argued, "[t]he responses to the 1981 Green Paper have shown, however, that circumstances vary so much in practice that a general solution will not be fair in all cases. It appears that no practical problems arise from the absence of specific authorship provisions in this area. *The Government has therefore concluded that no specific provisions should be made to determine this question*... If no human skill and effort has been expended then no work warranting copyright protection has been created."[19]

After this White Paper, the Copyright Committee of the British Computer Society (BCS) submitted a proposal to the Government arguing that CGWs should be protected as a distinct type of work. "The BCS proposes the creation of a new class of copyright protected works. The copyright owner or 'maker' should be defined as the person by whom the arrangements necessary for the making of that computer output or computer-generated work, are undertaken."[20] This language was essentially adopted in the CDPA. The BCS's proposed language was modeled after provisions for film authorship under the Copyright Act 1956. Despite the BCS's protestation that sound recordings, films, cable programmes and published editions were already being generated by computer, the CDPA did not extend protections to this subject matter for CGWs.

Since the CDPA's enactment, the authorship of CGWs was considered in *Nova Productions Ltd v Mazooma Games Ltd*.[21] In this case, the parties were competing manufacturers of electronic pool games. Nova claimed copyright in its graphics and the frames generated by software from those graphics and displayed to users during gameplay. Kitchin J (as he then was) regarded the frames which the software generated based on user actions to be CGWs, even though the component graphics of the frames were designed by a person. Kitchin J further held that the author of the CGW in this case was the company director responsible for designing the game—the person who designed the appearance of the various elements displayed, devised the rules and logic for frame generation, and wrote the program, and not the game player, who "…contributed no skill or labour of an artistic kind". It should be noted there was limited consideration of §9(3) in this case because the subsistence and ownership of the works was not contested.

In sum, while judicial experience with CGW copyright is limited, it is clear that copyright protection is available. The "author" of a CGW work is the person by whom the arrangements necessary for the creation of the work are undertaken. In light of the relative absence of case law related to authorship of CGWs, cases that have investigated authorship for films may be instructive. Under the CDPA, a film's producer and principal director are together deemed an author. A producer, "in relation to a sound recording or a film, means the person by whom the arrangements necessary for the making of the sound recording or film are undertaken…" CDPA

§178. Identifying a producer may be a fact intensive inquiry.[22] Cases have found it is relevant who instigated the making of the film, who paid for the making of the film, whether a film would not have existed but for the input of a person, whether more than one person may be a producer, and the extent of creative contributions.[23] Although jurisprudence in related areas may provide guidance, there is a degree of novelty to determining authorship of CGWs. It may not be clear in all cases whether the person who makes necessary arrangements is a computer's owner, user, or programmer.

United Kingdom Standards for Patenting Computer-Generated Works

By contrast to copyright, there is no statutory provision governing patents for CGWs, and there appear to have been no cases on the subject. The Patents Act 1977 ("PA") is the primary legislation for patent law. The PA protects inventions which are new, involve an inventive step, and are capable of industrial application. Patents grant their owners the exclusive right to make, use, sell and import an invention for a limited term, generally 20 years from the date an application is filed, subject to certain exceptions.

While nothing in the PA explicitly deals with CGWs, on numerous occasions it references natural persons. For example, the PA requires the identity of individual inventors to be disclosed, and inventors have the right to be mentioned in an application or a patent. It also provides benefits to inventors in some circumstances in which an employer has received outstanding benefit from an invention. The PA states that, "inventor… in relation to an invention means the actual deviser of the invention..." PA §7(3). The term "deviser" is not defined in the PA, but judicial language also frequently refers to inventors as persons and refers to concepts such as "mental activity" being necessary for invention.[24]

European Union Standards for Computer-Generated Works

The European Single Market seeks to guarantee the free movement of goods, capital, services and labour within the European Union. However, IPRs such as copyright and patents can create barriers to free trade. IPRs are largely national in origin, and not transferrable across boarders or mutually recognized per se. In the interest of promoting trade, the EU has attempted to centralize and harmonize national IP laws. This has been aided by case law from the Court of Justice of the European Union (CJEU), the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), which is discussed in the next section, and various EU directives.

Early CJEU cases established the doctrine of exhaustion and the specific subject matter doctrine. This allowed recognition of national IPRs, but limited the application of IPRs where they would limit free movement of goods. The EU is a party to TRIPS, which has harmonized to a great extent IPRs within the EU. Since TRIPS, various EU directives, such as the Computer Program Directive and the Database Directive, have increasingly harmonized national IP laws where differences existed in terms of substance or duration of rights.[25] Further efforts at harmonization have resulted in a unique EU trademark system, and various *sui generis* rights such as EU level plant variety rights. Today, there is relative comprehensive harmonization of some forms of IP such as trademarks, and relative greater discrepancy with copyright. (Elsmore, 2012).

There is no equivalent to the CDPA §9(3) in other EU continental jurisdictions.[26] Worldwide, the UK is one of only a handful of countries that explicitly permits copyright for CGWs. Other nations that provide protection, such as Ireland, New Zealand and India, were influenced by the UK's example—their statutory instruments contain similar language to CDPA §9(3).[27]

EU member states may not have laws specifically permitting or refusing copyright protection for CGWs, but many have laws that restrict authorship to natural persons. For example, Spanish copyright law states that the author of a work is the natural person who creates it.[28] Under French law, only natural persons who create works may be considered authors, and the rights to a work vest in the author regardless of any contract.[29] For collective works, a legal entity can exercise rights but is not classified as the author. Various other national instruments contain language that alludes to authorship as being a human activity. At a European level, the benchmark for originality is an "author's own intellectual creation." This concept was first introduced through legislation—the Software, Term and Database Directives—and then developed by the CJEU.[30] For example, in 2011, the CJEU held that, "copyright is liable to apply only in relation to a subject-matter, such as a photograph, which is original in the sense that is its author's own intellectual creation… the author of a portrait photograph can stamp the work created with his 'personal touch'."[31] This and similar language seems to imply an author is a natural person. CGWs are not explicitly discussed in any European directives.

For patents, as with the PA, the European Patent Convention (EPC) requires the identity of inventors to be disclosed in patent applications and issued patents,[32] although it is left to contracting states to resolve who is an inventor and other entitlement issues. The EPC is a multilateral treaty, separate from the EU and with different membership, which created the European Patent Organisation (EPO) and a system for granting "European patents." A European patent is not a centrally enforceable patent or a unitary right. Rather, the EPC provides a harmonized procedure for unified prosecution and opposition, on the basis of which a European patent may be nationally granted in any of the 38 EPO countries. By contrast, the European patent with unitary effect (EPUE), or the unitary patent, is a new type of European patent that would be valid in participating member states of the EU. This would involve a single patent and ownership, as well as a single court (the Unified Patent Court), and uniform protection. The *Agreement on a Unified Patent Court* establishes the unitary patent system. Participation is open to any member state of the EU, but not other parties to the EPC. Negotiations for the unitary patent have been ongoing since the 1970s. At present, this agreement will enter into force after it is ratified by Germany.

International Standards for Computer-Generated Works

Two of the most important international agreements governing copyright and patent law are the Berne Convention and the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS). For example, the Berne Convention required countries to offer the same level of copyright protection to nationals of other parties to the convention. It also introduced the idea that copyright protection is not contingent on formalities such as registration, though member states are free to require 'fixation'. The most substantive international IP agreement is TRIPS, which established global standards for copyright and patent protection. The UK and all EU Member States are required to adhere to the mandatory requirements in TRIPS. These requirements were modeled after the IP laws in developed nations such as the United Kingdom, United States and Japan, so TRIPS required relatively few changes to the UK's IP laws when it came into effect on 1 January 1996.[33]

Nothing in these, or any other binding international instrument, explicitly authorizes, or prohibits, protections for CGWs. The Berne Convention, for instance, states the Union is created, "for the protection of the rights of authors in their literary and artistic works."[34] However, the Convention does not define "author."[35] The Berne Convention Guide states that this is due to the fact that, "national laws diverge widely, some recognizing only natural persons as authors, while others treat certain legal entities as copyright owners."[36]

The World Intellectual Property Organization (WIPO) did consider protections of "computer-produced works" in discussions of a possible Model Copyright Law.[37] It defined a computer-produced work as one generated by a computer where identification of authors is impossible because of the indirect nature of individual contributions. The original owner of the moral and economic rights in such a work would be either the entity "by whom or by which the arrangements necessary for the creation of the work are undertaken," or the entity "at the initiative and under the responsibility of whom or of which the work is created and disclosed." WIPO's Committee of Experts eventually concluded further study was needed, and the model law was never adopted.

United States Standards for Computer-Generated Works

No statute governs the subject of CGWs in the US, and no cases have seriously considered copyright or patent protection for CGWs. However, the US Copyright Office has a policy prohibiting copyright for any non-human work—what it now refers to as its "human authorship requirement." The US Patent and Trademark Office (USPTO) does not have any stated policy regarding CGWs and patents. In 1986, Professor Pamela Samuelson wrote, "[a]s yet there has been no judicial decision allocating rights in computer-generated works. It can, however, only be a matter of time before courts are forced to resolve the issue."[38] That prediction proved optimistic.

One recent US case came close to raising the issue. *Naruto v. Slater* involved a series of pictures that a crested macaque took of itself. These "Monkey Selfies" were subsequently commercialized by the camera's owner, David Slater, who asserted he owned the copyright to the photographs. People for the Ethical Treatment of Animals (PETA) subsequently sued Mr. Slater, alleging that the macaque, Naruto, was the copyright owner, and that Mr. Slater had infringed Naruto's copyright.

In January 2016, US District Judge William Orrick III dismissed the case on the grounds that Naruto lacked standing to sue. The judge also deferred to the USPTO's interpretation that the macaque was not an "author" within the meaning of the Copyright Act. He considered PETA's argument that the USPTO policy is antithetical to the "public interest in animal art", but ultimately ruled "that is an argument that should be made to Congress and the President, not to me."[39] PETA appealed the decision to the Ninth Circuit Court of Appeals, and shortly after oral arguments, the parties reached a settlement in which Mr. Slater agreed to donate 25% of any future revenues from the monkey selfies to charities. Despite the settlement, however, the Ninth Circuit dismissed the case to create precedent. The Court held that animals only have statutory standing if an Act of Congress plainly states animals have statutory standing, and so animals are unable to sue under the Copyright Act because the law does not expressly authorize animals to file copyright infringement clams. In doing so, the court avoided weighing in on the merits of non-human authorship.

Outside of CGWs, US copyright law has a mechanism for authorship of artificial persons. "In the case of a work made for hire, the employer for whom the work was prepared is considered the author for purposes." 17 U.S.C. § 201(b) (2011). Functionally, the same outcome may occur in the UK, but while the UK permits employers to own works, ownership is distinct from authorship for so-called "author works"—literary, dramatic, musical or artistic works—the same works protected by CDPA §9(3). Even in EU countries where only natural persons may be authors, a focus on "author's rights" does not preclude authors from transferring certain rights to employers, and some jurisdictions will imply the existence of an agreement to do so. Ultimately, then, the same economic outcome may occur for works made in the course of employment in the US, UK and in EU civil law jurisdictions, but the terminology may differ. Some civil law jurisdictions may also retain additional, inalienable rights for authors.

IV. PROTECTING COMPUTER GENERATED WORKS

Policy

Various rationales are given for IPRs, but broadly speaking, they can function as economic incentives and they are justified on the basis of natural rights. The notion of IPRs as an economic right, particularly for patents, dominates the Anglo-American system. In the US, for example, the Constitution explicitly endorses an innovation incentive rationale for IPRs, by granting Congress the power "[t]o promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."[40]

Patents can incentivize innovation.[41] This is based on the theory that information goods are typically non-excludable and non-rivalrous, so lack of protection will lead to underproduction. By granting a limited monopoly in the form of a patent, this allows inventors to enjoy greater financial benefits from discoveries and encourages invention. In addition, patents can promote the commercialization of inventions. For instance, new drug approvals often take years, and the pharmaceutical industry claims that getting new drugs approved costs billions of pounds. Once a drug is approved, it may be easy for a competitor to copy the drug and avoid the costs of initial approval. Patents may thus encourage an originator pharmaceutical company to spend the necessary resources on approval, because after the drug is approved they can charge monopoly prices until patents expire. Patents, whether incentivizing research or commercialization, are thus one solution to the "freerider" problem. Finally, patents can promote information disclosure. Patents are issued to inventors in exchange for disclosing to the public how to make an invention. Without patents, inventors might rely on confidential information to prevent copying, and never publicly disclose how to make an invention. This happened, for example, with the drug "Premarin" which was first made by Wyeth and now is made by Pfizer. No generics company has been able to replicate this drug since its first regulatory approval in 1942. Perhaps most famously, Coca-Cola has kept its recipe for its iconic beverage confidential for over a century.

By contrast, the civil law systems of continental Europe may place more emphasis than the UK on moral rights, which are viewed as independently protectable and separate from economic rights. Moral rights protect an author's personality and the integrity of a work, and are considered "personal, perpetually inalienable and unassignable."[42] Moral rights also accommodate "personality" rights based, for instance, on theories by Kant and Hegel that people express their "wills" and develop as persons through their interactions with external objects. This, for instance, is accomplished by giving authors the right to control certain uses of their works, even after assigning economic rights. Personality theorists argue that authors and inventors are inherently at risk of having their ideas stolen or altered in objectionable ways. Thus, IPRs are justified to prevent misappropriation or modification of objects through which authors express themselves. IPRs also accommodate Lockean theories of first occupancy, the idea that the person who owns a particular thing should be the person who 'gets there first', as well as labour theory, the idea that ownership is derived from mixing labour with unowned or commonly held property, and that appropriating these products would be unjust. These ideals are reflected in patent law, for instance, by giving inventorship rights to the first inventor to file for a patent, and giving inventorship rights to individuals who find new uses for natural products.

But IPRs can also have significant costs. They restrict competition (particularly in the case of patents) and free speech (particularly in the case of copyright), and they can inhibit innovation, collaboration, and open communities. To the extent that IPRs are justified, it is because they are thought to have more benefits than costs. However, with IPRs, more is not always better. For instance, software patents have been criticized for being unnecessary as an incentive, while at the same time creating "patent thickets" that make work in the software industry challenging.[43] For this reason, the EPC states that "programs for computers" are not patentable, but the EPO will grant patents for "computer-impelmented inventions" as long as they have a technical effect.

Whether to Patent and to whom?

Having examined UK, EU and international laws on copyright and patent protection for CGWs, or the absence thereof, let us return to the question of whether the UK should provide patent protection for CGWs. A number of academic commentators have argued that CGWs should become public property.[44] If CGWs should instead be eligible for patent protection, who should be the inventor and owner of a CGW?

This chapter proposes that CGWs should be eligible for patent protection. The innovation incentive function of patents does not change based on whether a computer or a person invents. It is true that a computer does not respond to financial incentives, but the entities who develop inventive machines do. Providing patent protection for the output of autonomous machines makes autonomous machines more valuable, and what better way to incentivize innovation than to incentivize the development of inventive machines? This would reward activity upstream from the act of invention. To the extent that patents are incentivizing commercialization and disclosure of information, there is no change in this function as between a human and CGW. Also, if patent protection is not available for inventive AI output, then businesses may not use inventive AI, even in future instances where AI will be more effective than a person.

If CGWs are prohibited from receiving patents, it may be possible for a natural person to claim inventorship of a CGW even where that person was not involved in the development or operation of a computer. Namely, a person could argue they "devised" the invention by virtue of recognizing the relevance of a machine's output. Indeed, discovery of an unrecognized problem may give rise to patentable subject-matter ("problem-inventions").[45] Similarly, discovery of an unrecognized *solution* can be patentable. In some cases, recognition of the inventive nature of a computer's output may require significant skill, but in others, the nature of inventive output may be obvious. In the future, it may even be the case that a computer can identify its own output as patentable, and format it for a patent application.

If CGWs are to be protected, how then should inventorship and ownership be determined? Distinguishing inventorship and ownership may not functionally impact economic rights, but it does implicate moral rights. At present, *de jure* or *de facto*, individuals are claiming inventorship of CGWs under circumstances in which they have not functioned as inventors. This is fundamentally unfair, and it weakens moral justifications for patents by allowing individuals to take credit for the work of inventive machines. It is not unfair to computers who have no interest in being acknowledged, but it is unfair to other human inventors because it devalues their accomplishments by altering, and diminishing, the meaning of inventorship. This could equate the hard work of creative geniuses with those simply asking a computer to solve a problem. It would be particularly problematic once inventive machines come to generate a substantial portion, or even the majority of inventions.[46] By contrast, acknowledging computers as inventors would also acknowledge the work of computer programmers. While they may not have directly contributed to an invention, they may take credit for the success of their machines. This is similar to the way in which a supervisor may take pride in the success of a PhD student, without taking direct credit for their future writings and inventions.

If CGWs are to be protected, and a computer is to be acknowledged as an inventor, who should own the CGW? Certainly, computers should not own patents. Computers are non-sentient, cannot own property, and are themselves owned as property. Colin Davies has suggested the computer should hold IP rights and transfer these under contract.[47] He notes this would require machine "responsibility," which might require a deposit in a computer's name to satisfy adverse judgments or an insurance scheme. More simply, ownership may directly vest in a computer's user, programmer, or owner. In many instances, these may be the same entity, but they may also be distinct parties. The best policy or ideal solution would be to have ownership vest in the party that results in the most effective economic outcome, and also results in a standard that is practical to implement.[48]

The computer's owner should be the default owner of any CGW it produces. This is most consistent with current ownership norms surrounding personal property (including both computers and patents).[49] It should also most effectively incentivize innovation because it will motivate owners to share access to their software. If the computer's user is the default owner of a CGW, this may instead result in computer owners restricting access. Computer programmers do not need to own future CGWs because they will capture the increased value of an inventive machine upon selling it. Also, having ownership default to programmers would interfere with the transfer of a machine, and it would be logistically problematic for developers to monitor machines they no longer own. The case for having computer owners also have ownership of CGWs reveals another reason why computers should be acknowledged as inventors. If computers cannot be inventors and instead the first natural person to recognize a computer's invention becomes the inventor, this would give CGWs to computer users rather than owners. There is already precedent for assigning ownership in IPRs to an owner distinct from an author or inventors, such as with works for hire, joint authorship, films, etc.

This default was just be a starting point—computer users, owners and developers would be free to contract to different outcomes.

Computer-generated works—competition or collaboration?

The current definition of CGWs fails to take into account the fact that computers independently should qualify for authorship and inventorship, even when contributing to jointly authored works with natural persons. Computers may be inventors even of intermediate works. As such, the definition of CGWs should be amended from work "generated by a computer in circumstances such that there is no human author of the work", to work "generated by a computer in circumstances such that the computer, if a natural person, would meet authorship requirements." This would more accurately take into account contributions by machines, and allow economic incentives to work more efficiently.

The downside of this approach may be that it would be difficult for computer owners to know when their machines have generated CGWs. Users might benefit from failing to disclose CGWs to computer owners and then claiming they invented a CGW. However, users may still choose to disclose CGWs so that they could negotiate for clear title and, alternately, to avoid liability. To the extent that users and owners are distinct entities and users are licensing computers for purposes generating CGWs, users may choose to negotiate *a priori* for ownership of CGWs with computer owners.

Determining human inventorship is already a tricky business in collaborative works. It may be even more difficult for collaborative works involving a computer. There are a variety of ways for computers to invent, some of which involve more human intervention than others. For example, a programmer may design a computer program specifically to solve a particular problem, and the solution may be the patentable invention. In such an instance, the programmer might have a greater claim to inventorship, resulting in joint inventorship with a computer. Again, this is not unlike current inventorship criteria, where a variety of individuals can play greater or lesser roles in invention. However, the current definition of CGWs in the CDPA does not accommodate this reality for copyright, as it fails to take into account that a computer can jointly author a work with a person.

International Harmonization

Finally, there is a need for a harmonized approach to CGWs. If the UK grants copyright and patent protections for CGWs, it has to provide nationals of other EU member states and parties to TRIPS with the same rights. However, if these other parties fail to allow for CGWs in their own domestic laws, UK nationals may not receive reciprocal protections.[50] Few EU member states have dealt with CGWs.[51] Inventive machine owners might thus be unable to obtain IPRs outside the UK. In fact, disclosing a machine author or inventor in a UK application might prejudice IPRs in other jurisdictions. At least for an interim period, UK entities would be advised to identify a natural person as an author or inventor where possible to avoid an inequitable economic outcome.

Future treatment of CGWs within the EU might be dealt with by an EU directive or regulation, although Brexit may remove the UK from the direct effect of changes to EU law. Regardless of Brexit, UK nationals still should benefit under the national treatment rule of TRIPS from changes to EU law that ascribe machine authorship and inventorship for CGWs. CGWs might also be dealt with by a future multinational agreement. However, harmonization exercises at the international level tend to proceed at a glacial pace.

Concluding Thoughts

In October 2017, the Kingdom of Saudi Arabia announced it was granting citizenship to a humanoid robot, Sophia, manufactured by Hanson Robotics. It is unclear whether this announcement was merely intended for publicity, or whether the nation has actually granted Sophia citizenship. In any event, if Sophia is a Saudi citizen, because Saudi Arabia is a party to TRIPS, other WTO members may be obliged to provide for IPRs for Sophia's CGWs. Although, other countries may argue that Berne and TRIPs refer to *authors and inventors* who are nationals, but that machines cannot be authors and inventors regardless of 'nationality'. In any event, while granting legal personhood to a machine may be one way to try and avoid disparate treatment of CGWs at the international level, there are other reasons to disfavor such an approach.

The law is overdue for establishing clear standards for protection of CGWs. As AI continues to improve, such works will become increasingly important. Efficiently structured copyright and patent laws can help maximize the value of CGWs, and protect the moral rights of human authors and inventors.[52] However, for IPRs to function effectively, it is important that right holders and potential infringers have a reasonable degree of certainty about the scope and limits of protection.

[1] *See*, Ryan Abbott, *I Think, Therefore I Invent: Creative Computers and the Future of Patent Law*, 54 B. C. L. Rev. 1079–1126 (2016).
[2] *See*, Ryan Abbott, *Everything is Obvious*, 66 UCLA. L. Rev. 2 (2019).
[3] *See*, *e.g.*, Band-in-a-Box, PG Music, http://www.pgmusic.com.
[4] Arthur Miller, *Copyright Protection for Computer Programs , Databases , and Computer Generated Works: Is Anything New Since CONTU*? 106 Harvard Law Review 977–1073 (1993).
[5] Abbott, Ryan, The Reasonable Computer: Disrupting the Paradigm of Tort Liability, 86 Geo. Wash. L. Rev. 1 (2018) (discussing unexplainability in the context of AI).
[6] Patricia Holt, Sunday Review, S.F.CHRON., Aug. 15, 1993, B4; *see*, *generally*, Grimmelmann, J. *There's No Such Thing As A Computer-Authored Work,* 39 Columbia Journal of Law & the Arts 403, 408 (2016).
[7] U.S. COPYRIGHT OFFICE, COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES (FIRST) §2.8.3 (1st ed. 1973).
[8] Ryan Abbott, *I Think, Therefore I Invent: Creative Computers and the Future of Patent Law*, 54 B. C. L. Rev. 1079–1126 (2016).
[9] IDA Ltd and others v University of Southampton and others [2006] EWCA Civ 145; Abbott, Ryan, Jeremy Lack and David Perkins. Managing Disputes in the Life Sciences. Nature Biotechnology, 36, 697 (2018).
[10] Mueller Brass Co. v Reading Industries Inc. 176 USPQ 361 (1972).
[11] The CDPA permits copyright for "(a) original literary, dramatic, musical or artistic works, (b) sound recordings, films [or broadcasts], and (c) the typographical arrangement of published editions." CDPA 1988, § 1 (internal footnote and emphasis omitted).
[12] Copyright, Designs and Patents Act, 1988 §154.
[13] Copyright, Designs and Patents Act, 1988 §214.
[14] Copyright, Designs and Patents Act, 1988 §12(7).
[15] In the case of Cummins v. Bond in 1927, a court was asked to adjudicate copyright in a work allegedly written by a journalist while acting as a spiritual medium. Cummins v. Bond, 1 Ch. 167 (1927). The court was not willing to decide that "authorship and copyright rest with someone already domiciled on the other side of the inevitable river." *Id*. at 173. The rights to the work had to vest in a terrestrial being.
[16] A similar outcome occurred in the case of *The Jockey Club v Rahim* (unreported) 22 July 1983, which concerned computers generating lists of runners and riders for horse races.
[17] Whitford Committee on Copyright Designs and Performers Protection (Cmnd 6732 HMSO 1977), para 514.
[18] Reform of the Law Relating to Copyright, Designs and Performer's Protection, A Consultative Document 58 (Cmnd 8302 HMSO 1981).
[19] Intellectual Property and Innovation (Cmnd 9712; HMSO, Ch 9, paras 9.6–8).
[20] Robert Hart, *Copyright and computer generated works*, 40 Aslib Proceedings 173*,* 173–181 (1988).
[21] Nova Productions Ltd v Mazooma Games Ltd [2006] RPC 379. CGWs were also briefly considered in Bamgboye v Reed [2004] EMLR 5, 73 [38], Williamson J wrote that §9(3) "is dealing with the case where one is looking at a piece of music which, in fact, is composed of computerised sounds."
[22] *See*, *e.g.*, Beggars Banquet [1993] EMLR 349.
[23] Jani McCutcheon, *Curing the authorless void: Protecting computer-generated works following*

icetv and phone directories. 37 Melbourne University Law Review 46 (2013).

[24] *See, e.g., Yeda Research and Development Co Ltd v Rhone-Poulenc Rorer International Holdings Inc* [2007] UKHL 43, [2008] RPC 1 quoting Laddie J. in University of Southampton's Applications [2005] R.P.C. 11, [39] ("The inventor is defined in s.7(3) as 'the actual deviser of the invention'. The word 'actual' denotes a contrast with a deemed or pretended deviser of the invention; it means, as Laddie J. said in University of Southampton's Applications [2005] R.P.C. 11, [39], the natural person who 'came up with the inventive concept.'")

[25] Directive 2009/24/EC of the European Parliament and of the Council of 23 April 2009 on the legal protection of computer programs; Directive 96/9/EC of the European Parliament and of the Council of 11 March 1996 on the legal protection of databases.

[26] Andres Guadamuz, *Do androids dream of electric copyright? Comparative analysis of originality in artificial intelligence generated works*, Intellectual Property Quarterly 169 (2017).

[27] Copyright, Designs and Patents Act, 1988, c. 48, § 9(3) (U.K.); Copyright Act of 1994, § 5 (N.Z.); Copyright and Related Rights Act 2000, Part I, § 2 (Act. No. 28/2000) (Ir.).

[28] Ley 22/11 sobre la Propiedad Intelectual de 1987.

[29] C. IP. Art. L111-1 (2003).

[30] Case C-5/08 Infopaq International A/S v Danske Dagblades Forening [2009] ECR I-06569.

[31] Eva-Maria Painer v. Standard VerlagsGmbH and ors, Case C-145/10 [2011] ECDR (13) 297, 324, [AG121]. In that case, Advocate-General Trstenjak interpreted EU directives related to this language to mean that, "'only human creations are … protected', although these can 'include those for which the person employs a technical aid, such as a camera'." *Id*.

[32] EPC R. 19 (Designation of the inventor).

[33] 94/800/EC Council Decision (of 22 December 1994). *See*, *generally*, Matthew James Elsmore, *Comparing regulatory treatment of intellectual property at WTO and EU level,* in LIBERALISING TRADE IN THE EU AND THE WTO: A LEGAL COMPARISON 412–439 (Sanford E. Gaines, et al., eds., 2012).

[34] BERNE CONVENTION FOR THE PROTECTION OF LITERARY AND ARTISTIC 1971 ART. I.

[35] *Cf*, SAM RICKETSON AND JANE C. GINSBURG, INTERNATIONAL COPYRIGHT AND NEIGHBORING RIGHTS (2 VOLUMES): THE BERNE CONVENTION AND BEYOND (2nd Ed. 2006) (arguing the reference to 'makers' of cinematographic works is the exception rather than the rule, and that 'author' referring to natural persons would be most consistent with the moral rights provisions and durations of protection being based on the life of an author).

[36] WORLD INTELLECTUAL PROPERTY ORGANIZATION, GUIDE TO THE BERNE CONVENTION II (1978).

[37] *See* INTERNATIONAL BUREAU OF WIPO, PREPARATORY DOCUMENT, DRAFT MODEL ON COPYRIGHT at 258-59 (No. CD/MPC/III/2, Mar. 30, IggO).

[38] Pamela Samuelson, *Allocating ownership rights in computer-generated works.* 47 U. Pitt. Law Review 1185, 1190 (1985).

[39] Naruto v. David John Slater et al, No. 16-15469 (9th Cir. 2018).

[40] UNITED STATES CONSTITUTION, ARTICLE I, SECTION 8, CLAUSE 8 (emphasis added).

[41] WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW. Cambridge, MA: Belknap Press (2003).

[42] Martin A. Roeder, *The Doctrine of Moral Right: A Study in the Law of Artists, Authors and Creators*, 53 Harv. L. Rev. 554, 557 (1940). *See*, *also*, Graham Dutfield, *Collective Invention and Patent Law Individualism: Origins and Functions of the Inventor's Right of Attribution*. 5 The WIPO Journal 25, 27 (2013).

[43] Daniel J. Hemel & Lisa Larrimore Ouellette, *Beyond the Patents-Prizes Debate,* 92 TEX. L. REV. 303 (2013).
[44] *See*, *e.g.*, Ralph Clifford, *Intellectual Property in the Era of the Creative Computer Program: Will the True Creator Please Stand Up*? 71 Tul. L. Rev. 1675 (1997).
[45] *See*, *e.g.*, T 0002/83 (Simethicone Tablet) of 15.3.1984 (EPO Board of Appeal).
[46] *See*, Abbott, R. Everything is Obvious, 66 UCLA. L. Rev. 2 (2019).
[47] Colin Davies, *An evolutionary step in intellectual property rights - Artificial intelligence and intellectual property*. 27 Computer Law and Security Review 601, 615 (2011).
[48] Ryan Abbott, *Hal the Inventor: Big Data and its Use by Artificial Intelligence,* in BIG DATA IS NOT A MONOLITH (Hamid Ekbia, et al., eds.) (2016).
[49] Cf Schuster, W. Michael, 'A Coasean Analysis of Ownership of Patents for Inventions Created by Artificial Intelligence', 75 *Washington and Lee Law Review* (forthcoming 2018), <https://ssrn.com/abstract=3132753>. (arguing for user default ownership).
[50] Robert Hart, *Copyright and computer generated works*, 40 Aslib Proceedings 173*,* 173–181 (1988).
[51] Mark Perry & Thomas Margoni, *From music tracks to Google maps: Who owns computer-generated works*? 26 Computer Law and Security Review 621, 621–629 (2010).
[52] Ryan Abbott & Bret Bogenschneider, *Should Robots Pay Taxes? Tax Policy in the Age of Automation*, 12 Harv. L. & Pol. Rev. 145 (2018).

I THINK, THEREFORE I INVENT: CREATIVE COMPUTERS AND THE FUTURE OF PATENT LAW

RYAN ABBOTT*

Abstract: Artificial intelligence has been generating inventive output for decades, and now the continued and exponential growth in computing power is poised to take creative machines from novelties to major drivers of economic growth. In some cases, a computer's output constitutes patentable subject matter, and the computer rather than a person meets the requirements for inventorship. Despite this, and despite the fact that the Patent Office has already granted patents for inventions by computers, the issue of computer inventorship has never been explicitly considered by the courts, Congress, or the Patent Office. Drawing on dynamic principles of statutory interpretation and taking analogies from the copyright context, this Article argues that creative computers should be considered inventors under the Patent and Copyright Clause of the Constitution. Treating nonhumans as inventors would incentivize the creation of intellectual property by encouraging the development of creative computers. This Article also addresses a host of challenges that would result from computer inventorship, including the ownership of computer-based inventions, the displacement of human inventors, and the need for consumer protection policies. This analysis applies broadly to nonhuman creators of intellectual property, and explains why the Copyright Office came to the wrong conclusion with its Human Authorship Requirement. Finally, this Article addresses how computer inventorship provides insight into other areas of patent law. For instance, computers could replace the hypothetical skilled person that courts use to judge inventiveness. Creative computers may require a rethinking of the baseline standard for inventiveness, and potentially of the entire patent system.

INTRODUCTION

An innovation revolution is on the horizon.[1] Artificial intelligence ("AI") has been generating inventive output for decades, and now the contin-

* Professor of Law and Health Sciences, University of Surrey School of Law and Adjunct Assistant Professor, David Geffen School of Medicine at University of California, Los Angeles. Thanks to Ian Ayres, Martin Keane, John Koza, Lisa Larrimore-Ouellette, Mark Lemley, and Steven Thaler for their insightful comments.

[1] *See, e.g.*, JAMES MANYIKA ET AL., DISRUPTIVE TECHNOLOGIES: ADVANCES THAT WILL TRANSFORM LIFE, BUSINESS, AND THE GLOBAL ECONOMY 40 (2013) (predicting that the automation

ued and exponential growth in computing power is poised to take creative machines from novelties to major drivers of economic growth.[2] A creative singularity in which computers overtake human inventors as the primary source of new discoveries is foreseeable.

This phenomenon poses new challenges to the traditional paradigm of patentability. Computers already are generating patentable subject matter under circumstances in which the computer, rather than a human inventor, meets the requirements to qualify as an inventor (a phenomenon that this Article refers to as "computational invention").[3] Yet, it is not clear that a computer could be an inventor or even that a computer's invention could be patentable.[4] There is no statute addressing computational invention, no case law directly on the subject, and no pertinent Patent Office policy.[5]

These are important issues to resolve. Inventors have ownership rights in their patents, and failure to list an inventor can result in a patent being held invalid or unenforceable. Moreover, government policies encouraging or inhibiting the development of creative machines will play a critical role in the evolution of computer science and the structure of the research and development ("R&D") enterprise.[6] Soon computers will be routinely inventing, and it may only be a matter of time until computers are responsible for most innovation.

---

of knowledge work "could have as much as $5.2 trillion to $6.7 trillion in economic impact annually by 2025").

[2] *See infra* notes 275–278 and accompanying text.

[3] *See infra* notes 28–99 and accompanying text*; see also* Ryan Abbott, *Hal the Inventor: Big Data and Its Use by Artificial Intelligence*, *in* BIG DATA IS NOT A MONOLITH (Cassidy R. Sugimoto, Hamid R. Ekbia & Michael Mattioli eds., forthcoming Oct. 2016) (discussing computational invention in an essay originally posted online on February 19, 2015).

[4] *See, e.g.*, Ralph D. Clifford, *Intellectual Property in the Era of the Creative Computer Program: Will the True Creator Please Stand Up*?, 71 TUL. L. REV. 1675, 1681, 1702–03 (1997) (arguing the output of creative computers cannot and should not be protected by federal intellectual property laws and that such results enter the public domain); *see also* Pamela Samuelson, *Allocating Ownership Rights in Computer-Generated Works*, 47 U. PITT. L. REV. 1185, 1199–1200 (1986) (arguing that computers cannot be authors because they do not need incentives to generate output). Pamela Samuelson, arguing against considering computers to be authors, states that, "[o]nly those stuck in the doctrinal mud could even think that computers could be 'authors.'" *Id.* at 1200.

[5] *See* Ben Hattenbach & Joshua Glucoft, *Patents in an Era of Infinite Monkeys and Artificial Intelligence*, 19 STAN. TECH. L. REV. 32, 44 & n.70 (2015) (noting no pertinent results from "a search for patent cases discussing genetic programming or computer-aided drug discovery (perhaps the two most common means of computerized inventive activity)" and that "[o]f a sampling of issued patents that were conceived wholly or in part by computers, none have ever been subject to litigation."); *see also* ROBERT PLOTKIN, THE GENIE IN THE MACHINE 60 (2009). "Patent Office" refers to the U.S. Patent and Trademark Office ("USPTO"), the federal agency responsible for granting patents and registering trademarks. *See About Us*, USPTO, http://www.uspto.gov/about-us [https://perma.cc/6HZY-V9NU] (last visited Jan. 27, 2016).

[6] *See generally* Michael Kremer & Heidi Williams, *Incentivizing Innovation: Adding to the Tool Kit*, 10 INNOVATION POL'Y & ECON. 1 (2010) (discussing the importance of intellectual property rights for promoting innovation).

This Article addresses whether a computer could and should be an inventor for the purposes of patent law as well as whether computational inventions could and should be patentable.[7] It argues that computers can be inventors because although AI would not be motivated to invent by the prospect of a patent, computer inventorship would incentivize the development of creative machines.[8] In turn, this would lead to new scientific advances.

Beyond inventorship concerns, such machines present fascinating questions: Are computers thinking entities? Who should own the rights to a computer's invention? How do animal artists differ from artificial intelligence? What would be the societal implications of a world in which most inventions were created by computers? Do creative computers challenge established norms in other areas of patent law? This Article attempts to resolve these questions as well as some of the other philosophical, societal, and even apocalyptic concerns related to creative computers.[9]

This Article is divided into three parts.[10] Part I examines instances in which AI has created patentable inventions.[11] It finds that machines have been autonomously generating patentable results for at least twenty years and that the pace of such invention is likely increasing.[12] It proceeds to discuss the criteria for inventorship and to examine the roles of humans and computers in the inventive process. It concludes that statutory language requiring inventors to be individuals and judicial characterization of invention as a "mental act" present barriers to computer inventorship, but that otherwise computers independently meet the requirements for inventorship. Finally, Part I notes that applicants seem not to be disclosing the role of creative computers to the Patent Office—likely as a result of uncertainty over whether a computer inventor would render an invention unpatentable. Applicants may also be able to legally circumvent such disclosure by being the first human to discover a computer's patentable result, but this Article will discuss how that approach is unfair, inefficient, and logistically problematic.

Part II examines the jurisprudence related to nonhuman authorship of copyrightable material in the absence of law on the subject of computer inventorship.[13] It discusses the history of the Copyright Office's Human Authorship

[7] *See infra* notes 23–138 and accompanying text.
[8] *See infra* notes 139–239 and accompanying text.
[9] *See infra* notes 230–313 and accompanying text.
[10] *See infra* notes 23–138, 139–239, and 240–312 and accompanying text.
[11] *See infra* notes 23–138 and accompanying text.
[12] *See, e.g.*, John R. Koza, *Human-Competitive Results Produced by Genetic Programming*, *in* 11 GENETIC PROGRAMMING & EVOLVABLE MACHINES 251, 251 (2010) [hereinafter Koza, *Human-Competitive Results*] ("[T]he increased availability of computing power (through both parallel computing and Moore's law) should result in the production, in the future, of an increasing flow of human-competitive results, as well as more intricate and impressive results.").
[13] *See infra* notes 139–239 and accompanying text.

Requirement,[14] and scrutinizes case law interpreting the Patent and Copyright Clause.[15] On the basis of this analysis, and based on principles of dynamic statutory interpretation,[16] it argues that computers should qualify as legal inventors.

This would incentivize the development of creative machines consistent with the purpose and intent of the Founders and Congress. The requirement that inventors be individuals was designed to prevent corporate ownership,[17] and so computer inventorship should not be prohibited on this basis. Also, there should be no requirement for a mental act because patent law is concerned with the creativity of an invention itself rather than the subjective mental process by which an invention may have been achieved.[18] This Part concludes by addressing objections to computer inventorship including arguments that computational inventions would develop in the absence of patent protection at non-monopoly prices.

Finally, Part III addresses challenges posed by computer inventorship, and generalizes the analysis of earlier sections.[19] It finds that a computer's owner should be the default assignee of any invention, both because this is most consistent with the rules governing ownership of property, and because it would most incentivize innovation. Where a computer's owner, developer, and user are different entities, such parties could negotiate alternative arrangements by contract. Computer ownership here generally refers to software ownership, although there may be instances in which it is difficult to distinguish between hardware and software, or even to identify a software "owner."[20] This Part also examines the phenomenon of automation and the displacement of human inventors by computers. It finds that computational invention remains beneficial despite legitimate concerns and that for the foreseeable future computers are likely to refocus human inventors rather than replace them.

Part IV concludes by finding the arguments in support of computer inventorship apply with equal force to nonhuman authors. Allowing animals to create copyrightable material would result in more socially valuable art by creating new incentives for people to facilitate animal creativity.[21] It would also

---

[14] *See* U.S. COPYRIGHT OFFICE, COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES § 306 (3d ed. 2014).

[15] *See* U.S. CONST. art. I, § 8, cl. 8.

[16] *See generally* William N. Eskridge, Jr., *Dynamic Statutory Interpretation*, 135 U. PA. L. REV. 1479 (1987) (identifying principles of dynamic statutory interpretation).

[17] *See infra* notes 122–132 and accompanying text.

[18] *See, e.g.*, *The "Flash of Genius" Standard of Patentable Invention*, 13 FORDHAM L. REV. 84, 85–86 (1944).

[19] *See infra* notes 240–312 and accompanying text.

[20] *See generally* GOVERNMENT OFFICE FOR SCIENCE, DISTRIBUTED LEDGER TECHNOLOGY: BEYOND BLOCK CHAIN (describing algorithmic technologies and distributed ledgers as examples of new and disruptive computational paradigms).

[21] *See infra* notes 279–287 and accompanying text.

provide incentives for environmental conservation.[22] Lastly, this Article examines some of the implications of computer inventorship for other areas of patent law. Computers are a natural substitute for the person having ordinary skill in the art ("PHOSITA" or, simply, the "skilled person") used to judge a patent's inventiveness. The skilled person is presumed to know of all the prior art (what came before an invention) in a particular field—a legal fiction that could be accurate in the case of a computer. Substituting a computer for the skilled person also suggests a need to expand the scope of prior art, given that computers are not limited by human distinctions of scientific fields. This would make it more challenging for inventions to be held nonobvious, particularly in the case of inventions that merely combine existing elements in a new configuration (combination patents). That would be a desirable outcome, although the new test would create new challenges.

I. Creative Computers and Patent Law

This Part investigates instances when AI has created patentable inventions.[23] It finds that machines have been autonomously generating patentable results for at least twenty years and that the pace of such invention is likely increasing.[24] This Part proceeds to discuss the criteria for inventorship and to examine the roles of humans and computers in the inventive process.[25] It concludes that statutory language requiring inventors to be individuals and judicial characterizations of invention as a "mental act" present barriers to computer inventorship, but that computers independently meet the requirements for inventorship otherwise.[26] Finally, this Part notes that applicants seem not to be disclosing the role of creative computers to the Patent Office—likely as a result of uncertainty over whether a computer inventor would render an invention unpatentable.[27]

A. Computers Independently Generate Patentable Results

1. Example One: The Creativity Machine

Computers have been autonomously creating inventions since the twentieth century. In 1994, computer scientist Stephen Thaler disclosed an invention

---

[22] *See infra* notes 279–287 and accompanying text.

[23] *See infra* notes 23–138 and accompanying text.

[24] *See, e.g.*, Koza, *Human-Competitive Results*, *supra* note 12, at 251 ("[T]he increased availability of computing power (through both parallel computing and Moore's law) should result in the production, in the future, of an increasing flow of human-competitive results, as well as more intricate and impressive results.").

[25] *See infra* notes 100–121 and accompanying text.

[26] *See infra* notes 122–132 and accompanying text.

[27] *See infra* notes 133–138 and accompanying text.

he called the "Creativity Machine," a computational paradigm that "came the closest yet to emulating the fundamental mechanisms responsible for idea formation."[28] The Creativity Machine is able to generate novel ideas through the use of a software concept referred to as artificial neural networks—essentially, collections of on/off switches that automatically connect themselves to form software without human intervention.[29]

At its most basic level, the Creativity Machine combines an artificial neural network that generates output in response to self-stimulation of the network's connections together with another network that perceives value in the stream of output.[30] This results in an AI that "brainstorms" new and creative ideas after it alters (perturbs) the connections within its neural network.[31] An example of this phenomenon occurred after Dr. Thaler exposed the Creativity Machine to some of his favorite music, and the machine proceeded to write eleven thousand new songs in a single weekend.[32]

Dr. Thaler compares the Creativity Machine and its processes to the human brain and consciousness.[33] The two artificial neural networks mimic the human brain's major cognitive circuit: the thalamo-cortical loop.[34] In a simplified model of the human brain, the cortex generates a stream of output (or consciousness), and the thalamus brings attention (or awareness) to ideas that are of interest.[35] Like the human brain, the Creativity Machine is capable of generating novel patterns of information rather than simply associating patterns, and it is capable of adapting to new scenarios without additional human input.[36] Also like the human brain, the AI's software is not written by human beings—

---

[28] *See What Is the Ultimate Idea?*, IMAGINATION ENGINES INC., http://www.imagination-engines.com [https://perma.cc/P877-F33B] (last visited Jan. 25, 2016).

[29] The architecture for the Creativity Machine is discussed in greater detail in several publications. *See, e.g.*, Stephen L. Thaler, *Synaptic Perturbation and Consciousness*, 6 INT'L J. MACHINE CONSCIOUSNESS 75 (2014) [hereinafter Thaler, *Synaptic Perturbation and Consciousness*]; Stephen Thaler, *Creativity Machine® Paradigm*, *in* ENCYCLOPEDIA OF CREATIVITY, INVENTION, INNOVATION, AND ENTREPRENEURSHIP 451 (Elias G. Carayannis ed., 2013) [hereinafter Thaler, *Creativity Machine® Paradigm*]; S.L. Thaler, *A Proposed Symbolism for Network-Implemented Discovery Processes*, WORLD CONGRESS ON NEURAL NETWORKS '96, SAN DIEGO 1265 (Int'l Neural Network Soc'y 1996) [hereinafter, Thaler, *A Proposed Symbolism*].

[30] *See* Aaron M. Cohen, *Stephen Thaler's Imagination Machines*, THE FUTURIST, July–Aug. 2009, at 28, 28–29.

[31] *See* Thaler, *A Proposed Symbolism*, *supra* note 29, at 1265–68.

[32] *See* Tina Hesman, *Stephen Thaler's Computer Creativity Machine Simulates the Human Brain*, ST. LOUIS POST-DISPATCH, Jan. 24, 2004, *available at* http://www.mindfully.org/Technology/2004/Creativity-Machine-Thaler24jan04.htm [https://perma.cc/T8HS-C2TB].

[33] Thaler, *Creativity Machine® Paradigm*, *supra* note 29, at 447.

[34] *Id.*

[35] *Id.*

[36] *See Artificial Neural Networks*, IMAGINATION ENGINES INC., http://imagination-engines.com/iei_ann.php [https://perma.cc/BB8K-G3FH] (last visited Jan. 25, 2016); *IEI's Patented Creativity Machine® Paradigm*, IMAGINATION ENGINES INC., http://imagination-engines.com/iei_cm.php [https://perma.cc/4A8A-6H3Y] (last visited Jan. 25, 2016).

it is self-assembling.[37] Dr. Thaler argues his AI is very different from a software program that simply generates a spectrum of possible solutions to a problem combined with an algorithm to filter for the best ideas generated.[38] He notes that such a software program would be another method for having an AI developing novel ideas.[39]

Dr. Thaler invented the Creativity Machine, and the machine was the subject of his first patent, titled "Device for the Autonomous Generation of Useful Information."[40] The second patent filed in Dr. Thaler's name was "Neural Network Based Prototyping System and Method."[41] Dr. Thaler is listed as the patent's inventor, but he states that the Creativity Machine invented the patent's subject matter (the "Creativity Machine's Patent").[42] The Creativity Machine's Patent application was first filed on January 26, 1996, and granted on December 22, 1998.[43]

As one of Dr. Thaler's associates observed in response to the Creativity Machine's Patent, "Patent Number Two was invented by Patent Number One. Think about that. Patent Number Two was invented by Patent Number One!"[44] Aside from the Creativity Machine's Patent, the machine is credited with numerous other inventions: the cross-bristle design of the Oral-B CrossAction toothbrush, new super-strong materials, and devices that search the Internet for messages from terrorists, among others.[45]

The Creativity Machine's Patent is interesting for a number of reasons. If Dr. Thaler's claims are accurate, then the Patent Office has already granted, without knowing it has done so, a patent for an invention created by a non-human inventor—and as early as 1998. Also, the Patent Office apparently had no idea it was doing so. Dr. Thaler listed himself as the inventor on the patent

---

[37] *See* Cohen, *supra* note 29.

[38] *See* Telephone Interview with Stephen Thaler, President and CEO, Imagination Engines, Inc. (Jan. 10, 2016) [hereinafter Thaler, Telephone Interview].

[39] *See id.*

[40] *See* U.S. Patent No. 5,659,666 (filed Oct. 13, 1994).

[41] *See* U.S. Patent No. 5,852,815 (filed May 15, 1998).

[42] *See Patent Listing*, IMAGINATION ENGINES INC., http://imagination-engines.com/iei_ip.php [https://perma.cc/N79N-NWEF] (last visited Jan. 25, 2016).

[43] U.S. Patent No. 5,852,815 (filed May 15, 1998). This application is a divisional of application with serial number 08/592,767 filed Jan. 26, 1996. This means the patent was invented sometime before January 26, 1996. Patent applications require an inventor to actually or constructively possess the invention at the time an application is filed to meet enablement and written description requirements. *See* U.S. PATENT & TRADEMARK OFFICE, MANUAL OF PATENT EXAMINING PROCEDURE § 2164 (9th ed. Rev 7, Nov. 2015) [hereinafter MPEP].

[44] Hesman, *supra* note 32 (quoting Rusty Miller).

[45] Thaler, *Creativity Machine® Paradigm*, *supra* note 29, at 451. Table 1 contains a list of Creativity Machine accomplishments. *Id.*

and did not disclose the Creativity Machine's involvement to the Patent Office. The patent's prosecution history contains no mention of a computer inventor.[46]

2. Example Two: The Invention Machine

The Creativity Machine has not been the only source of computational invention.[47] Software modeled after the process of biological evolution, known as Genetic Programming ("GP"), has succeeded in independently generating patentable results. [48] Evolution is a creative process that relies on a few simple processes: "mutation, sexual recombination, and natural selection."[49] GP emulates these same methods digitally to achieve machine intelligence.[50] It delivers human-competitive intelligence with a minimum amount of human involvement.[51]

As early as 1996, GP succeeded in independently generating results that were the subject of past patents.[52] By 2010, there were at least thirty-one instances in which GP generated a result that duplicated a previously patented invention, infringed a previously issued patent, or created a patentable new invention.[53] In seven of those instances, GP infringed or duplicated the functionality of a twenty-first century invention.[54] Some of those inventions were on the cutting edge of research in their respective fields.[55] In two instances, GP may have created patentable new inventions.[56]

---

[46] The file history for this patent is available from a search of the USPTO's website. *Patent Application Information Retrieval*, USPTO, http://portal.uspto.gov/pair/PublicPair [https://perma.cc/7PAM-3EG7] (last visited Jan. 27, 2016). Patent applicants have a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to be material to patentability. 37 C.F.R. § 1.56 (2012). Indeed, Dr. Thaler completed an inventor's oath or declaration stating that he disclosed to the Office all information known to be material to patentability including the identity of all inventors. *See* 35 U.S.C. § 115 (2012); MPEP, *supra* note 43, § 602.01(b) (listing the standard for patents filed before September 16, 2012). Such oaths are made under penalty of fine or imprisonment, and willful false statements may jeopardize the validity of an application and any future patents. 35 U.S.C. § 115; MPEP, *supra* note 43, § 602.01(a)–(b).

[47] *See generally* Jon Rowe & Derek Partridge, *Creativity: A Survey of AI Approaches*, 7 ARTIFICIAL INTELLIGENCE REV. 43 (1993) (detailing sources of computational inventions).

[48] Koza, *Human-Competitive Results*, *supra* note 12, at 265. Alan Turing identified GP as a method of creating machine intelligence in his 1950 report *Intelligent Machinery*. A.M. TURING, INTELLIGENT MACHINERY 18 (1948) ("[T]he genetical or evolutionary search by which a combination of genes is looked for, the criterion being the survival value.").

[49] John R. Koza et al., *Evolving Inventions*, SCI. AM., Feb. 2003, at 52.

[50] *See id.*

[51] *See id.*

[52] *See* Koza, *Human-Competitive Results*, *supra* note 12, at 255–56, 265.

[53] *See id.*

[54] *See id.*

[55] *See* Koza et al., *Evolving Inventions*, *supra* note 49, at 52.

[56] Koza, *Human-Competitive Results*, *supra* note 12, at 265. These two instances are the inventive act described in U.S. Patent No. 6,847,851 (filed July 12, 2002) and JOHN R. KOZA ET AL., GENETIC PROGRAMMING IV: ROUTING HUMAN-COMPETITIVE MACHINE INTELLIGENCE 102–04 (2003).

The Patent Office granted another patent for a computational invention on January 25, 2005.[57] That invention was created by the "Invention Machine"—the moniker for a GP-based AI developed by John Koza.[58] Dr. Koza is a computer scientist and pioneer in the field of GP, and he claims the Invention Machine has created multiple "patentable new invention[s]."[59] A 2006 article in *Popular Science* about Dr. Koza and the Invention Machine claimed that the AI "has even earned a U.S. patent for developing a system to make factories more efficient, one of the first intellectual-property protections ever granted to a nonhuman designer."[60] The article refers to a patent titled "Apparatus for Improved General-Purpose PID and non-PID Controllers" (the "Invention Machine's Patent").[61] The Invention Machine generated the content of the patent without human intervention and in a single pass.[62] It did so without a database of expert knowledge and without any knowledge about existing controllers.[63] It simply required information about basic components (such as resistors and diodes) and specifications for a desired result (performance measures such as voltage and frequency).[64] With this information, the Invention Machine proceeded to generate different outputs that were measured for fitness (whether an output met performance measures).[65]

Once again, the Patent Office seems to have had no idea of the AI's role in the Invention Machine's Patent.[66] The *Popular Science* article states that Dr. Koza did not disclose the Invention Machine's involvement, and the patent's

---

[57] Jonathon Keats, *John Koza Has Built an Invention Machine*, POPULAR SCI. (Apr. 18, 2006), http://www.popsci.com/scitech/article/2006-04/john-koza-has-built-invention-machine [https://web.archive.org/web/20150218225133/http://www.popsci.com/scitech/article/2006-04/john-koza-has-built-invention-machine].

[58] Dr. Koza was also the inventor of the scratch-off lottery ticket in the 1970s. *See Home Page of John R. Koza*, GENETIC PROGRAMMING, http://www.genetic-programming.com/johnkoza.html [https://perma.cc/H77Y-XM4T] (last visited Aug. 8, 2016).

[59] *See* Koza, *Human-Competitive Results*, *supra* note 12, at 265.

[60] Keats, *supra* note 57.

[61] *See id*; U.S. Patent No. '851 (filed July 12, 2002). Although the article does not specifically identify the patent it is referring to, a search of USPTO records reveals only one patent with Dr. Koza listed as an inventor and with a grant date of January 25, 2005. In addition, in 2010, Dr. Koza subsequently identified the 851 Patent as one of two examples in which GP created a patentable new invention. *See* Koza, *Human-Competitive Results*, *supra* note 12, at 265.

[62] KOZA ET AL., GENETIC PROGRAMMING IV, *supra* note 56, at 102–04.

[63] Telephone Interview with John Koza, President, Genetic Programming Inc. (Jan. 22, 2016) [hereinafter Koza, Telephone Interview].

[64] *Id*.

[65] Thus, the GP algorithm is domain independent. Unlike human inventors who often have extensive knowledge of prior inventions and who proceed to build on earlier work, the GP algorithm generated a new controller without any reliance on prior art.

[66] "If the Turing test had been to fool a patent examiner instead of a conversationalist, then January 25, 2005 would have been a date for the history books." PEDRO DOMINGOS, THE MASTER ALGORITHM: HOW THE QUEST FOR THE ULTIMATE LEARNING MACHINE WILL REMAKE OUR WORLD 133–34 (2015).

prosecution history contains no mention of a computer inventor.[67] Dr. Koza states that his legal counsel advised him at the time that his team should consider themselves inventors despite the fact that "the whole invention was created by a computer."[68]

Dr. Koza reports that his agenda in having the Invention Machine recreate previously patented results was to prove that computers could be made to solve problems automatically.[69] He believed that focusing on patentable results would produce compelling evidence that computers were producing something valuable.[70] For that reason, he focused on recreating or inventing patentable subject matter that represented significant scientific advances.[71] For instance, the Invention Machine's Patent was for an improved version of a landmark controller built in 1995.[72]

3. Example Three: Watson

The Creativity Machine and the Invention Machine may be the earliest examples of computer inventors, but others exist.[73] Moreover, the exponential growth in computing power over the past dozen years combined with the increasing sophistication of software should have led to an explosion in the

---

[67] Indeed, all three of the inventors on the '851 patent, including Dr. Koza, completed an inventor's oath or declaration stating that they disclosed to the Office all information known to be material to patentability including the identity of all inventors.

[68] Koza, Telephone Interview, *supra* note 63.

[69] *Id.*

[70] *Id*.

[71] *Id.* Generating these results *de novo* thus represented a test with an external measure of difficulty, in contrast to other AI researchers who were training computers to complete academic exercises.

[72] *See generally* KARL J. ASTROM & TORE HAGGLUND, PID CONTROLLERS: THEORY, DESIGN, AND TUNING (2d ed. 1995) (detailing original version of the controller for which the Invention Machine created an improved, patentable version).

[73] *E.g.*, Matrix Advanced Solutions used AI to develop a new anticoagulant. *See* Daniel Riester et al., *Thrombin Inhibitors Identified by Computer-Assisted Multiparameter Design*, 102 PROC. NAT'L ACAD. SCI. USA 8597, 8597–602 (2005). Maxygen Inc. used GP to develop a novel Hepatitis C treatment. *See Maxygen's Next-Generation Interferon Alpha Enters Phase Ia Clinical Trial*, MAXYGEN (Nov. 7, 2006), *available at* http://www.prnewswire.com/news-releases/maxygens-next-generation-interferon-alpha-enters-phase-ia-clinical-trial-56073027.html [https://perma.cc/Y9LD-B9EL]. In fact, there is an annual competition for computers producing human-competitive results by genetic and evolutionary computation. *See Humies Awards*, SIGEVO-GECCO, http://sig.sigevo.org/index.html/tiki-index.php?page=Humies+Awards [https://perma.cc/XMG2-DAGY] (last visited Aug. 9, 2016). Dr. Koza states that competition participants have gone on to patent their results. Koza, Telephone Interview, *supra* note 63. For additional examples of "Artificial Inventions," see Plotkin, *supra* note 5, at 61. In his book, Dr. Plotkin uses the metaphor of a genie to argue that AI will change the dynamics of human-computer collaborations. He suggests that humans will write "wishes" (an abstract description of a machine or a set of instructions for creating a machine) for AI to "grant" (by producing the design for a machine or an actual machine). He further argues that fear of invention automation is unnecessary, and that individuals will become more sophisticated at "writing wishes" (defining problems) for AI to solve. He suggests this will result in more skilled inventors and non-inventors becoming inventors with the help of machines. *Id.* at 1–11.

number of computational inventions.[74] Indeed, it is likely that computers are inventing more than ever before.[75] Consider, for instance, the results produced by IBM's AI "Watson" of *Jeopardy!* fame.[76] Watson is a computer system developed by IBM to compete on the game show *Jeopardy!*[77] In 2011, it beat former *Jeopardy!* winners Ken Jennings and Brad Rutter on the show, earning a million dollars in the process.[78]

IBM describes Watson as one of a new generation of machines capable of "computational creativity."[79] IBM uses that term to describe machines that can generate "ideas the world has never imagined before."[80] Watson "generates millions of ideas out of the quintillions of possibilities, and then predicts which ones are [best], applying big data in new ways."[81] This is a fundamentally different type of AI than the Creativity Machine or the Invention Machine; Watson utilizes a more conventional architecture of logical deduction combined with access to massive databases containing accumulated human knowledge and expertise.[82] Although Watson is not modeled after the human brain or evo-

---

[74] *See, e.g.*, *50 Years of Moore's Law*, INTEL, http://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html [https://perma.cc/PMN9-XJ2L] (last visited Jan. 26, 2016). In 1965, Gordon Moore, co-founder of Intel and Fairchild Semiconductor, published a paper in which he noted a doubling every year in the number of components in an integrated circuit. Based on this and his subsequent observations, "Moore's Law" became the "golden rule for the electronics industry," predicting that overall processing power for computers will double every eighteen months. *See id*.

[75] *See, e.g.*, Koza, *Human-Competitive Results*, *supra* note 12, at 251 (stating that "the increased availability of computing power (through both parallel computing and Moore's Law) should result in the production, in the future, of an increasing flow of human-competitive results, as well as more intricate and impressive results").

[76] *See* Jo Best, *IBM Watson*, TECHREPUBLIC, http://www.techrepublic.com/article/ibm-watson-the-inside-story-of-how-the-jeopardy-winning-supercomputer-was-born-and-what-it-wants-to-do-next/ [https://perma.cc/BQ4V-Q48F] (last visited Jan. 17, 2016).

[77] *See id.*

[78] *See id.*

[79] *See Computational Creativity*, IBM, http://www.research.ibm.com/cognitive-computing/computational-creativity.shtml#fbid=kwG0oXrjBHY [https://perma.cc/6FK4-WTL3] (last visited Jan. 25, 2016).

[80] *What Is Watson?*, IBM, http://www.ibm.com/smarterplanet/us/en/ibmwatson/what-is-watson.html [https://perma.cc/8KM3-LLSG] (last visited Jan. 25, 2016). Watson is a cognitive commuting system with the extraordinary ability to analyze natural language processing, generate and evaluate hypotheses based on the available data then store and learn from the information. In other words, Watson essentially mirrors the human learning process by getting "smarter [through] tracking feedback from its users and learning from both successes and failures." *Id*. Watson made its notable debut on the game show Jeopardy, where it defeated Brad Rutter and Ken Jennings using only stored data by comparing potential answers and ranking confidence in accuracy at the rate of approximately three seconds per question. *Id*.

[81] *Computational Creativity*, *supra* note 79.

[82] *See, e.g.*, David Ferrucci et al., *Building Watson: An Overview of the DeepQA Project*, AI MAG., Fall 2010, at 59, 68–69; *IBM Watson: Beyond Jeopardy! Q&A*, ACM, http://learning.acm.org/webinar/lally.cfm [https://perma.cc/JA3N-J6HG] (last visited Jan. 25, 2016).

lutionary processes, it is also capable of generating novel, nonobvious, and useful ideas.

Watson's *Jeopardy!* career was short and sweet, and by 2014, it was being applied to more pragmatic challenges, such as running a food truck.[83] IBM developed new algorithms for Watson and incorporated a database with information about nutrition, flavor compounds, the molecular structure of foods, and tens of thousands of existing recipes.[84] This new design permits Watson to generate recipes in response to users inputting a few parameters such as ingredients, dish (e.g., burgers or burritos), and style (e.g., British or dairy-free).[85] On the basis of this user input, Watson proceeds to generate a staggeringly large number of potential food combinations.[86] It then evaluates these preliminary results based on novelty and predicted quality to generate a final output.[87]

It is likely that some of Watson's discoveries in food science are patentable.[88] Patents may be granted for any "new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof."[89] Food recipes can qualify as patentable subject matter on this basis because lists of ingredients combine to form new compositions of matter or manufacture and the steps involved in creating food may be considered a process.[90] To be patentable, however, an invention must not only contain patentable subject matter; it must also be novel, nonobvious, and useful.[91] That may be challenging to achieve in the case of food recipes given that there is a finite number of ingredients and people have been combining ingredients together for a

---

[83] *See* Maanvi Singh, *Our Supercomputer Overlord Is Now Running a Food Truck*, NPR (Mar. 4, 2014), http://www.npr.org/blogs/thesalt/2014/03/03/285326611/our-supercomputer-overlord-is-now-running-a-food-truck [https://perma.cc/V7KM-X8P5]; *Chef Watson*, IBM, https://www.ibmchefwatson.com/community [https://perma.cc/2D54-UURY] (last visited Jan. 17, 2016); *Under the Hood*, IBM, http://www.ibm.com/smarterplanet/us/en/cognitivecooking/tech.html [https://perma.cc/HWQ8-SEFE] (last visited Jan. 17, 2016).

[84] *See Under the Hood*, *supra* note 83.

[85] *See Watson Cooks Up Computational Creativity*, IBM, http://www.ibm.com/smarterplanet/us/en/innovation_explanations/article/florian_pinel.html [https://perma.cc/GGV7-NHT4] (last visited Jan. 17, 2016).

[86] *See id.*

[87] *See id.*

[88] *See Can Recipes Be Patented?*, INVENTORS EYE (June 2013), http://www.uspto.gov/inventors/independent/eye/201306/ADVICE.jsp [https://perma.cc/EN3V-9DY4]; *see also* Diamond v. Chakrabarty, 447 U.S. 303, 308– 09 (1980) (noting that patentable subject matter "include[s] anything under the sun that is made by man" (quoting S. REP. NO. 82-1979, at 5 (1952); H.R. REP. NO. 82-1923, at 6 (1952))) (internal quotation marks omitted).

[89] 35 U.S.C. § 101 (1952).

[90] *See Can Recipes Be Patented?*, *supra* note 88.

[91] *See General Information Concerning Patents*, USPTO, http://www.uspto.gov/patents-getting-started/general-information-concerning-patents [https://perma.cc/J88J-YUVA] (Oct. 2014).

very long time.[92] Not only would Watson have to create a recipe that no one had previously created, but it could not be an obvious variation on an existing recipe. Still, people do obtain patents on new food recipes.[93] The fact that some of Watson's results have been surprising to its developers and to human chefs is encouraging[94] in this regard[95] because unexpected results are one of the factors considered in determining whether an invention is nonobvious.[96]

Watson is not limited to competing on *Jeopardy!* or to developing new food recipes.[97] IBM has made Watson broadly available to software application providers, enabling them to create services with Watson's capabilities.[98] Watson is now assisting with financial planning, helping clinicians to develop treatment plans for cancer patients, identifying potential research study participants, distinguishing genetic profiles that might respond well to certain drugs, and acting as a personal travel concierge.[99]

---

[92] *See* Therese Oneill, *7 of the World's Oldest Foods Discovered by Archeologists*, MENTAL FLOSS (Oct. 8, 2015), http://mentalfloss.com/article/49610/7-world%E2%80%99s-oldest-food-finds [https://perma.cc/Y9C5-DRGP].

[93] *See, e.g.*, U.S. Patent No. 8,354,134 (filed Dec. 22, 2005).

[94] Which is not to say that patents on recipes are a social good. *See generally* KAL RAUSTIALA & CHRISTOPHER SPRIGMAN, THE KNOCKOFF ECONOMY: HOW IMITATION SPARKS INNOVATION (2012) (discussing social ills that can arise from patents).

[95] *See, e.g.*, Rochelle Bilow, *How IBM's Chef Watson Actually Works*, BON APPÉTIT (June 30, 2014), http://www.bonappetit.com/entertaining-style/trends-news/article/how-ibm-chef-watson-works [https://perma.cc/5UAB-VAGW].

[96] MPEP, *supra* note 43, § 716.02(a).

[97] IBM has even worked with food magazine *Bon Appétit* to develop a recipe app called Chef Watson to allow the general public to enlist Watson's help in making new recipes. Rochelle Bilow, *We Spent a Year Cooking with the World's Smartest Computer—and Now You Can, Too*, BON APPÉTIT (June 23, 2015), http://www.bonappetit.com/entertaining-style/trends-news/article/chef-watson-app [https://perma.cc/HF7Q-C9FM]. Chef Watson can be accessed online at https://www.ibmchefwatson.com/community [https://perma.cc/2D54-UURY]. For the less technologically inclined who still wish to sample machine cooking, IBM has published a book of Watson's recipes. *See generally* IBM & THE INST. OF CULINARY EDUC., COGNITIVE COOKING WITH CHEF WATSON: RECIPES FOR INNOVATION FROM IBM & THE INSTITUTE OF CULINARY EDUCATION (2015) (detailing recipes created by Watson).

[98] *Watson Cooks Up Computational Creativity*, *supra* note 85.

[99] Anna Edney, *Doctor Watson Will See You Now, if IBM Wins in Congress*, BLOOMBERG BNA HEALTH IT LAW & INDUSTRY REPORT (Jan. 29, 2015), *available at* http://www.post-gazette.com/frontpage/2015/01/29/Doctor-Watson-will-see-you-now-if-IBM-wins-in-Congress/stories/201501290332 [https://perma.cc/4BHU-VJXU]; Thor Olavsrud, *10 IBM Watson-Powered Apps That Are Changing Our World*, CIO (Nov. 6, 2014), http://www.cio.com/article/2843710/big-data/10-ibm-watson-powered-apps-that-are-changing-our-world.html#slide11 [https://perma.cc/NPY7-DDMA].

B. Human and Computer Involvement in Computational Inventions

1. Requirements for Inventorship

All patent applications require one or more named inventors who must be "individuals," a legal entity such as a corporation cannot be an inventor.[100] Inventors own their patents as a form of personal property that they may transfer by "assignment" of their rights to another entity.[101] A patent grants its owner "the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States."[102] If a patent has multiple owners, each owner may independently exploit the patent without the consent of the others (absent a conflicting contractual obligation).[103] This makes the issue of whether a computer can be an inventor one of practical as well as theoretical interest because inventors have ownership rights in their patents, and failure to list an inventor can result in a patent being held invalid or unenforceable.[104]

For a person to be an inventor, the person must contribute to an invention's "conception."[105] Conception refers to, "the formation in the mind of the inventor of a definite and permanent idea of the complete and operative invention as it is thereafter to be applied in practice."[106] It is "the complete perfor-

---

[100] *See* 35 U.S.C. § 100(f) (1952) "The term 'inventor' means the individual or, if a joint invention, the individuals collectively who invented or discovered the subject matter of the invention." *See id*. The same issues surrounding computer inventorship may not exist outside of the U.S. where applications do not require a named inventor. *See* MPEP, *supra* note 43, § 2137.01 ("The requirement that the applicant for a patent in an application filed before September 16, 2012 be the inventor(s) . . . and that the inventor . . . be identified in applications filed on or after September 16, 2012, are characteristics of U.S. patent law not generally shared by other countries."). For example, a patent application at the European Patent Office may be filed by "any body equivalent to a legal person by virtue of the law governing it." Convention on the Grant of European Patents art. 58, Oct. 5, 1973, 1065 U.N.T.S. 199. Under the U.S. Patent Act, only individuals can invent, not corporations. *See* 35 U.S.C. §§ 115–116.

[101] *See* MPEP, *supra* note 43, § 300. About ninety-three percent of patents are assigned to organizations (rather than individuals). *See Patenting by Organizations (Utility Patents)*, USPTO, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/topo_13.htm#PartA1_1b [https://perma.cc/VF56-GFVT] (last modified Jan. 25, 2016). For example, it is common for scientific and technical workers to preemptively assign their patent rights to employers as a condition of employment. Most, but not all, inventions can be placed under an obligation of assignment in employment contracts. For example, in California, employees are permitted to retain ownership of inventions that are developed entirely on their own time without using their employer's equipment, supplies, facilities, or trade secret information except for inventions that either: related, at the time of conception or reduction to practice of the invention, to the employer's business; actual or demonstrably anticipated research or development of the employer; or resulted from any work performed by the employee for the employer. CAL. LAB. CODE § 2872(a) (West 1979).

[102] 35 U.S.C. § 154.

[103] *See* MPEP, *supra* note 43, § 2137.

[104] *See, e.g.*, Advanced Magnetic Closures, Inc. v. Rome Fastener Corp., 607 F.3d 817, 829 (Fed. Cir. 2010).

[105] MPEP, *supra* note 43, § 2137.01(II).

[106] Townsend v. Smith, 36 F.2d 292, 295 (C.C.P.A. 1929).

mance of the mental part of the inventive act."[107] After conception, someone with ordinary skill in the invention's subject matter (e.g., a chemist if the invention is a new chemical compound) should be able to "reduce the invention to practice."[108] That is to say, they should be able to make and use an invention from a description without extensive experimentation or additional inventive skill.[109] Individuals who simply reduce an invention to practice, by describing an already conceived invention in writing or by building a working model from a description for example, do not qualify as inventors.[110]

2. The Role of Computers in Inventive Activity

The requirement that an inventor participate in the conception of an invention creates barriers to inventorship for computers as well as people. Although computers are commonly involved in the inventive process, in most cases, computers are essentially working as sophisticated (or not-so-sophisticated) tools. One example occurs when a computer is functioning as a calculator or storing information. In these instances, a computer may assist a human inventor to reduce an invention to practice, but the computer is not participating in the invention's *conception*. Even when computers play a more substantive role in the inventive process, such as by analyzing data in an auto-

---

[107] *Id.*

[108] Reduction to practice refers to either actual reduction—where it can be demonstrated the claimed invention works for its intended purpose (for example, with a working model)—or to constructive reduction—where an invention is described in writing in such a way that it teaches a person of ordinary skill in the subject matter to make and use the invention (as in a patent application). *See In re* Hardee, 223 U.S.P.Q. (BNA) 1122, 1123 (Com'r Pat. & Trademarks Apr. 3, 1984); *see also* Bd. of Educ. *ex rel.* Bd. of Trs. of Fla. State Univ. v. Am. Bioscience, Inc., 333 F.3d 1330, 1340 (Fed. Cir. 2003) ("Invention requires conception."). With regard to the inventorship of chemical compounds, an inventor must have a conception of the specific compounds being claimed. *See Am. Bioscience*, 333 F.3d at 1340 ("[G]eneral knowledge regarding the anticipated biological properties of groups of complex chemical compounds is insufficient to confer inventorship status with respect to specifically claimed compounds."); *see also Ex parte* Smernoff, 215 U.S.P.Q 545, 547 (Pat. & Tr. Office Bd.App. Aug. 17,1982) ("[O]ne who suggests an idea of a result to be accomplished, rather than the means of accomplishing it, is not a coinventor."). Actual reduction to practice "requires that the claimed invention work for its intended purpose." Brunswick Corp. v. United States, 34 Fed. Cl. 532, 584 (1995) (quotations omitted) (quoting Hybritech Inc. v. Monoclonal Antibodies, Inc., 802 F.2d 1367, 1376 (Fed. Cir. 1986). Constructive reduction to practice "occurs upon the filing of a patent application on the claimed invention." *Id*. The written description requirement is "to ensure that the inventor had possession, as of the filing date of the application relied on, of the specific subject matter later claimed by him." *Application of* Edwards, 568 F.2d 1349, 1351 (C.C.P.A. 1978).

[109] "[C]onception is established when the invention is made sufficiently clear to enable one skilled in the art to reduce it to practice without the exercise of extensive experimentation or the exercise of inventive skill." Hiatt v. Ziegler & Kilgour , 179 U.S.P.Q. 757, 763 (Bd. Pat. Interferences Apr. 3, 1973). Conception has been defined as a disclosure of an idea that allows a person skilled in the art to reduce the idea to a practical form without "exercise of the inventive faculty." Gunter v. Stream, 573 F.2d 77, 79 (C.C.P.A. 1978).

[110] *See* De Solms v. Schoenwald, 15 U.S.P.Q. 2d 1507, 1510 (Bd.Pat.App.& Interferences. Feb. 22, 1990).

mated fashion, retrieving stored knowledge, or by recognizing patterns of information, the computer still may fail to contribute to conception. Computer involvement might be conceptualized on a spectrum: on one end, a computer is simply a tool assisting a human inventor; on the other end, the computer independently meets the requirements for inventorship. AI capable of acting autonomously such as the Creativity Machine and the Invention Machine fall on the latter end of the spectrum.

3. The Role of Humans in Inventive Activity

Just as computers can be involved in the inventive process without contributing to conception, so can humans. For now, at least, computers do not entirely undertake tasks on their own accord. Computers require some amount of human input to generate creative output.

For example, before the Creativity Machine composed music, Dr. Thaler exposed it to existing music and instructed it to create something new.[111] Yet, simply providing a computer with a task and starting materials would not make a human an inventor.[112] Imagine Friend *A* tells Friend *B*, who is an engineer, that *A* would like *B* to develop an iPhone battery with twice the standard battery life and *A* gives *B* some publically available battery schematics. If *B* then succeeds in developing such a battery, *A* would not qualify as an inventor of the battery by virtue of having instructed *B* to create a result.[113] This scenario essentially occurred in the case of the Creativity Machine's toothbrush invention: Dr. Thaler provided the Creativity Machine information on existing toothbrush designs along with data on each brush's effectiveness.[114] Solely from this information, the Creativity Machine produced the first ever crossed-bristle design.[115] This does not make Dr. Thaler an inventor. In the case of the Creativity Machine, the creative act is the result of random or chaotic perturbations in the machine's existing connections that produce new results which, in turn, are judged by the machine for value.[116]

Humans are also necessarily involved in the creative process because computers do not arise from a void; in other words, humans have to create computers.[117] Once again, that should not prevent computer inventorship. No

---

[111] Thaler, Telephone Interview, *supra* note 38.

[112] *Ex parte* Smernoff, 215 U.S.P.Q. at 547 ("[O]ne who suggests an idea of a result to be accomplished, rather than the means of accomplishing it, is not a coinventor.").

[113] *See id.*

[114] Thaler, Telephone Interview, *supra* note 38.

[115] *Id.*

[116] *See* Thaler, *Creativity Machine® Paradigm*, *supra* note 29, at 449.

[117] This will be the case until computers start designing other computers or engaging in reflection. Reflection is a software concept that refers to a computer program that can examine itself and modify its own behavior (and even its own code). J. Malenfant et al., *A Tutorial on Behavioral Reflection and Its Implementation*, *in* PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE REFLECTION 1, 1–

one would exist without their parents contributing to their conception (pun intended), but that does not make parents inventors on their child's patents. If a computer scientist creates an AI to autonomously develop useful information and the AI creates a patentable result in an area not foreseen by the inventor, there would be no reason for the scientist to qualify as an inventor on the AI's result. An inventor must have formed a "definite and permanent idea of the complete and operative invention" to establish conception.[118] The scientist might have a claim to inventorship if he developed the AI to solve a particular problem, and it was foreseeable that the AI would produce a particular result.[119]

4. Combining Human and Computer Creativity

A computer may not be a sole inventor; the inventive process can be a collaborative process between human and machine. If the process of developing the Creativity Machine's Patent had been a back-and-forth process with both the AI and Dr. Thaler contributing to conception, then both might qualify as inventors.[120] By means of illustration, suppose a human engineer provides a machine with basic information and a task. The engineer might learn from the machine's initial output, then alter the information that he or she provides to the machine to improve its subsequent output. After several iterations, the machine might produce a final output that the human engineer might directly alter to create a patentable result. In such a case, both the engineer and the machine might have played a role in conception. Leaving AI aside, invention is rarely occurs in a vacuum, and there are often joint inventors on patents.[121] In some of these instances, if a computer were human, it would be an inventor. Yet, computers are not human, and, as such, they face unique barriers to qualifying as inventors.

---

20 (1996), *available at* http://www2.parc.com/csl/groups/sda/projects/reflection96/docs/malenfant/malenfant.pdf [https://perma.cc/7EKK-7BJT].

[118] *Townsend*, 36 F.2d at 295.

[119] *See generally* Shyamkrishna Balganesh, *Foreseeability and Copyright Incentives*, 122 HARV. L. REV. 1569 (2009) (discussing foreseeability in the patent context).

[120] What is required is some "quantum of collaboration or connection." Kimberly-Clark Corp. v. Procter & Gamble Distrib. Co., 973 F.2d 911, 917 (Fed. Cir. 1992). For joint inventorship, "there must be some element of joint behavior, such as collaboration or working under common direction, one inventor seeing a relevant report and building upon it or hearing another's suggestion at a meeting." *Id.*; *see also* Moler & Adams v. Purdy, 131 U.S.P.Q. 276, 279 (Bd. Pat. Interferences 1960) ("[I]t is not necessary that the inventive concept come to both [joint inventors] at the same time.").

[121] *See* Prerna Wardhan & Padmavati Manchikanti, *A Relook at Inventors' Rights*, 18 J. INTELL. PROP. RIGHTS 168, 169 (2013).

C. Barriers to Computer Inventorship

1. The Legal Landscape

Congress is empowered to grant patents on the basis of the Patent and Copyright Clause of the Constitution.[122] That clause enables Congress "[t]o promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries."[123] It also provides an explicit rationale for granting patent and copyright protection, namely to encourage innovation under an incentive theory.[124] The theory goes that people will be more inclined to invent things (i.e., promote the progress of science) if they can receive government-sanctioned monopolies (i.e., patents) to exploit commercial embodiments of their inventions. Having the exclusive right to sell an invention can be tremendously lucrative.[125]

The Patent Act, which here refers to United States patent law as a whole, provides at least a couple of challenges to computers qualifying as inventors under the Patent and Copyright Clause.[126] First, as previously mentioned, the Patent Act requires that inventors be "individuals."[127] This language has been in place since at least the passage of legislation in 1952 that established the basic structure of modern patent law.[128] The "individual" requirement likely was included to reflect the constitutional language that specifically gives "in-

---

[122] U.S. CONST. art. I, § 8, cl. 8. This clause is also sometimes referred to as the "Patent Clause" or the "Copyright Clause."

[123] *Id.*

[124] *See* Mark A. Lemley, *Ex Ante Versus Ex Post Justifications for Intellectual Property*, 71 U. CHI. L. REV. 129, 129 (2004) ("The standard justification for intellectual property is ex ante . . . . It is the prospect of the intellectual property right that spurs creative incentives.").

[125] *See* JOHN STUART MILL, PRINCIPLES OF POLITICAL ECONOMY WITH SOME OF THEIR APPLICATIONS TO SOCIAL PHILOSOPHY 563 (Prometheus Books 2004) (1872) (noting that under a patent system, "the greater the usefulness, the greater the reward").

[126] Legislation pertaining to patents is found under Title 35 of the United States Code. The Patent Act may also be used to refer to specific pieces of legislation ranging from the Patent Act of 1790, the first patent law passed by the federal government, to the Patent Act of 1952. Pub. L. No. 82-593, 66 Stat. 792 (1952).

[127] *E.g.*, 35 U.S.C. § 100(f) ("The term 'inventor' means the individual or, if a joint invention, the individuals collectively who invented or discovered the subject matter of the invention."). The same issues surrounding computer inventorship may not exist outside of the U.S. where applications do not require a named inventor. *See* MPEP, *supra* note 43, § 2137.01 ("The requirement that the applicant for a patent in an application filed before September 16, 2012 be the inventor(s), . . . and that the inventor . . . be identified in applications filed on or after September 16, 2012, are characteristics of U.S. patent law not generally shared by other countries."). For example, a patent application at the European Patent Office may be filed by "any body equivalent to a legal person by virtue of the law governing it." Convention on the Grant of European Patents, *supra* note 100, at art. 58; *see also* 35 U.S.C. §§ 115–116.

[128] Pub. L. No. 82-593, 66 Stat. 792 (1952); *see also* Gregory Dolin, *Dubious Patent Reform*, 56 B.C. L. REV. 881, 889 (2015) (discussing aims of 1952 Patent Act).

ventors" the right to their discoveries as opposed to other legal entities that might assert ownership rights.[129] Such language would help to ensure that patent rights were more likely to go to individual inventors than to corporate entities where ownership was disputed.[130] Legislators were not thinking about computational inventions in 1952.[131] Second, patent law jurisprudence requires that inventions be the result of a "mental act."[132] So, because computers are not individuals and it is questionable that they engage in a mental act, it is unclear whether a computer autonomously conceiving of a patentable invention could legally be an inventor.

2. Avoiding Disclosure of Artificially Intelligent Inventors

Given that computers are functioning as inventors, and likely inventing at an escalating rate, it would seem that the Patent Office should be receiving an increasing number of applications claiming computers as inventors. That the Patent Office has not suggests that applicants are choosing not to disclose the role of AI in the inventive process.[133] That may be due to legal uncertainties about whether an AI inventor would render an invention unpatentable.[134]

---

[129] In the words of the United States Court of Appeals for the Federal Circuit, "people conceive, not companies." New Idea Farm Equip. Corp. v. Sperry Corp., 916 F.2d 1561, 1566 n.4 (Fed. Cir. 1990).

[130] Now under the America Invents Act ("AIA"), a corporate entity can apply for a patent on behalf of an inventor who is under an assignment obligation. MPEP, *supra* note 43, § 325.

[131] *See* Karl F. Milde, Jr., *Can a Computer Be an "Author" or an "Inventor"?*, 51 J. PAT. OFF. SOC'Y 378, 379 (1969). As one commentator notes:

> The closest that the Patent Statute comes to requiring that a patentee be an actual person is in the use, in Section 101, of the term "whoever." Here too, it is clear from the absence of any further qualifying statements that the Congress, in considering the statute in 1952, simply overlooked the possibility that a machine could ever become an inventor.

Id.; *see also, e.g.*, A.M. Turing, *Computing Machinery and Intelligence*, 59 MIND 433, 433–51 (1950) [hereinafter Turing, *Computing Machinery and Intelligence*].

[132] Conception has been defined as "the complete performance of the mental part of the inventive art," and it is "the formation in the mind of the inventor of a definite and permanent idea of the complete and operative invention as it is thereafter to be applied in practice." *Townsend*, 36 F.2d at 295.

[133] *See supra* note 5 and accompanying text. The discussion in note 5 infers that the Patent Office has not received applications claiming computers as inventors because they have no policy or guidance on the subject, they do not seem to have ever addressed the issue in any publication, and because computer inventorship does not seem to have been at issue in any patent litigation.

[134] *See, e.g.*, Dane E. Johnson, *Statute of Anne-imals: Should Copyright Protect Sentient Nonhuman Creators?*, 15 ANIMAL L. 15, 23 (2008) (quoting one Copyright Office employee who explained that "[as] a practical matter[,] the Copyright Office would not register [a computer's own] work if its origins were accurately represented on the copyright application. The computer program itself would be registerable if it met the normal standards for computer programs, but not the computer-generated literary work.") Despite this policy and the Copyright Office's Compendium guidelines, numerous computer-authored works have been registered. *See, e.g.*, William T. Ralston, *Copyright in Computer-Composed Music: Hal Meets Handel*, 52 J. COPYRIGHT SOC'Y OF THE U.S.A. 281, 283 (2004) (noting

Without a legal inventor, new inventions would not be eligible for patent protection and would enter the public domain after being disclosed.[135]

There is another reason why computers might not be acknowledged: a person can qualify as an inventor simply by being the first individual to recognize and appreciate an existing invention.[136] That is to say, someone can discover rather than create an invention. Uncertainty (and accident) is often part of the inventive process.[137] In such cases, an individual need only understand the importance of an invention to qualify as its inventor.[138] For the purposes of this Article, assuming that a computer cannot be an inventor, individuals who subsequently "discover" computational inventions by mentally recognizing and appreciating their significance would likely qualify as inventors. So, it may be the case that computational inventions are only patentable when an individual subsequently discovers them.

II. In Support of Computer Inventors

This Part examines the law regarding non-human authorship of copyrightable material.[139] It discusses the history of the Copyright Office's Human Authorship Requirement.[140] This Part also scrutinizes case law interpreting the Patent and Copyright Clause.[141] On the basis of this analysis and principles of dynamic statutory interpretation, this Part argues that computers should qualify as legal inventors.[142] This would incentivize the development of creative ma-

---

one computer-authored volume of poetry registered to a computer author, "Racter," but still not explicitly disclosed to be a computer). In 1993, Scott French programmed a computer to write in the style of a famous author, and the resulting work was registered as an "original and computer aided text." Tal Vigderson, Comment, *Hamlet II: The Sequel? The Rights of Authors vs. Computer-Generated "Read-Alike" Works*, 28 Loy. L.A. L. Rev. 401, 402–03 (1994). The novel was apparently terrible. *See* Patricia Holt, *Sunday Review*, S.F. Chron., Aug. 15, 1993, B4 ("[t]he result is a mitigated disaster").

[135] *See* MPEP, *supra* note 43, § 2137.

[136] Conception requires contemporaneous recognition and appreciation of the invention. *See* Invitrogen Corp. v. Clontech Labs., Inc., 429 F.3d 1052, 1064 (Fed. Cir. 2005) (noting that the inventor must have actually made the invention and understood the invention to have the features that comprise the inventive subject matter at issue); *see also, e.g.*, Silvestri v. Grant, 496 F.2d 593, 597 (C.C.P.A. 1974) ("[A]n accidental and unappreciated duplication of an invention does not defeat the patent right of one who, though later in time, was the first to recognize that which constitutes the inventive subject matter.").

[137] For instance, Alexander Fleming discovered penicillin in a mold that had contaminated his samples of Staphylococcus. Howard Markel, *The Real Story Behind Penicillin*, PBS (Sep. 27, 2013), http://www.pbs.org/newshour/rundown/the-real-story-behind-the-worlds-first-antibiotic/ [https://perma.cc/V6SM-2QJL].

[138] *See Silvestri*, 496 F.2d at 597.

[139] *See infra* notes 139–239 and accompanying text.

[140] Compendium of U.S. Copyright Office Practices, *supra* note 14, § 306.

[141] U.S. Const. art. I, § 8, cl. 8.

[142] *See generally* Eskridge, *Dynamic Statutory Interpretation*, *supra* note 16 (discussing canons of statutory interpretation).

chines consistent with the purpose and intent of the Founders and Congress. The requirement that inventors be individuals was designed to prevent corporate ownership, and, therefore, computer inventorship should not be prohibited on this basis.[143] Also, there should be no requirement for a mental act because patent law is concerned with the nature of an invention itself rather than the subjective mental process by which an invention may have been achieved.[144] This Part concludes by addressing objections to computer inventorship including arguments that computational inventions would develop in the absence of patent protection at non-monopoly prices.[145]

A. Nonhuman Authors of Copyrightable Material

The Patent Act does not directly address the issue of a computer inventor. The Patent Office has never issued guidance addressing the subject, and there appears to be no case law on the issue of whether a computer could be an inventor. That is the case despite the fact that the Patent Office appears to have already granted patents for inventions by computers but, as previously discussed, did so unknowingly.

There is, however, guidance available from the related issue of nonhuman authorship of copyrightable works.[146] Nonhuman authorship is not governed by statute, but there is interesting case law on the subject. Also, since at least 1984 the Copyright Office has conditioned copyright registration on human authorship.[147] In its 2014 compendium, the Copyright Office published an updated "Human Authorship Requirement" which states that:

> To qualify as a work of "authorship" a work must be created by a human being. . . . The Office will not register works produced by nature, animals, or plants. . . . Similarly, the Office will not register

---

[143] *See infra* notes 206–208 and accompanying text.

[144] *See, e.g.*, *The "Flash of Genius" Standard of Patentable Invention*, *supra* note 18, at 86.

[145] *See* notes 189–239 and accompanying text.

[146] The issue of computer authorship (and inventorship) has been considered "since the 1960s when people began thinking about the impact of computers on copyright." Arthur R. Miller, *Copyright Protection for Computer Programs, Databases, and Computer-Generated Works: Is Anything New Since CONTU?*, 106 HARV. L. REV. 977, 1043 (1993). Most of the literature related to computer generated works has focused on copyright rather than patent protection. "In the secondary literature on copyright, rivers of ink are spilt on" whether computers can be considered authors. MELVILLE B. NIMMER & DAVID NIMMER, NIMMER ON COPYRIGHT § 5.01[A] (LexisNexis 2015).

[147] COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES, *supra* note 14, § 202.02(b). The *Compendium of U.S. Copyright Office Practices* elaborates on the "human authorship" requirement by stating: "The term 'authorship' implies that, for a work to be copyrightable, it must owe its origin to a human being. Materials produced solely by nature, by plants, or by animals are not copyrightable." *Id.* It further elaborates on the phrase "[w]orks not originated by a human author" by stating: "In order to be entitled to copyright registration, a work must be the product of human authorship. Works produced by mechanical processes or random selection without any contribution by a human author are not registrable." *Id.* § 503.03(a).

> works produced by a machine or mere mechanical process that operates randomly or automatically without any creative input or intervention from a human author.[148]

This policy was the result of many years of debate within the Copyright Office.[149]

The requirement is based on jurisprudence that dates long before the invention of modern computers to the *In re Trade-Mark Cases* in 1879, in which the U.S. Supreme Court interpreted the Patent and Copyright Clause to exclude the power to regulate trademarks.[150] In interpreting this clause, the Court stated, in dicta, that the term "writings" may be construed liberally but noted that only writings that are "original, and are founded in the creative powers of the mind" may be protected.[151]

The issue of computer authorship was implicit in the Court's celebrated case of *Burrow-Giles Lithographic Co. v. Sarony* in 1884.[152] In that case, a lithographic company argued that a photograph of Oscar Wilde did not qualify as a "writing" or as the work of an "author."[153] The company further argued that even if a visual work could be copyrighted, that a photograph should not qualify for protection because it was just a mechanical reproduction of a natural phenomenon and thus could not embody the intellectual conception of its author.[154] The Court disagreed, noting that all forms of writing "by which the ideas in the mind of the author are given visible expression" were eligible for copyright protection.[155] The Court stated that although ordinary photographs might not embody an author's "idea," in this particular instance, the photographer had exercised enough control over the subject matter that it qualified as an original work of art.[156] Therefore, the case explicitly addressed whether the camera's involvement negated human authorship, and it implicitly dealt with

[148] *Id.* § 313.2.

[149] *See, e.g.*, U.S. COPYRIGHT OFFICE, EIGHTY-SECOND ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS 18 (1979) (discussing issues related to computer authorship).

[150] *See generally In re* Trade-Mark Cases, 100 U.S. 82 (1879) (finding that the Patent and Copyright Clause excludes regulating trademarks). Congress, which does indeed enjoy the ability to regulate trademarks, passed the Trade Mark Act of 1881 two years after this case was decided. That Act gave Congress the authority to regulate trademarks on the basis of the Commerce Clause.

[151] *Id*. at 94. The Court in this case held that only original works of art, which are the "fruits of intellectual labor," may be protected under copyright law. *Id.* (emphasis omitted).

[152] *See* Burrow-Giles Lithographic Co. v. Sarony, 111 U.S. 53, 56 (1884).

[153] *Id.*

[154] *Id.* at 58–59.

[155] *Id.* at 58.

[156] *Id.* at 54–55. Protections for all photographs was eventually made a part of the statutory scheme for copyright protection. 17 U.S.C. § 106A (2012). In the words of Judge Learned Hand, "no photograph, however simple, can be unaffected by the personal influence of the author, and no two will be absolutely alike." Jewelers' Circular Pub. Co. v. Keystone Pub. Co., 274 F. 932, 934 (S.D.N.Y. 1921), *aff'd*, 281 F. 83 (2d Cir. 1922).

the question of whether a camera could be considered an author. Though it seems unwise to put much emphasis on dicta from more than a century ago to resolve the question of whether nonhumans could be authors, the Copyright Office cites *Burrow-Giles* in support of its Human Authorship Requirement.[157]

The Copyright Office first addressed the issue of computer authors in 1966 when the Register of Copyrights, Abraham Kaminstein, questioned whether computer-generated works should be copyrightable.[158] Mr. Kaminstein reported that, in 1965, the Copyright Office had received applications for computer-generated works including: an abstract drawing, a musical composition, and compilations that were, at least partly, the work of computers.[159] Mr. Kaminstein did not announce a policy for dealing with such applications but suggested the relevant issue should be whether a computer was merely an assisting instrument (as with the camera in *Burrow-Giles*) or whether a computer conceived and executed the traditional elements of authorship.[160]

In the following years, the Copyright Office struggled with how to deal with computers more broadly.[161] At that time, copyright law did not even address the issue of whether computer software should be copyrightable—a far more urgent and financially important problem.[162]

In 1974, Congress created the Commission on New Technological Uses of Copyrighted Works ("CONTU") to study issues related to copyright and computer-related works.[163] With regards to computer authorship, CONTU wrote in 1979 that there was no need for special treatment of computer-generated works because computers were not autonomously generating creative results without human intervention; computers were simply functioning as tools to assist human authors.[164] CONTU also declared that autonomously creative AI was not immediately foreseeable.[165] The Commission unanimously concluded that "[w]orks created by the use of computers should be afforded copyright protection if they are original works of authorship within the Act of 1976."[166] According to the Commission, "the author is [the] one who employs

---

[157] *See* COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES, *supra* note 14, § 306.

[158] *See* U.S. COPYRIGHT OFFICE, SIXTY-EIGHTH ANN. REP. REG. COPYRIGHTS 4–5 (1966).

[159] *Id.*

[160] *See id.*

[161] *See* Act of Dec. 31, 1974, Pub. L. No. 93-573, § 201, 88 Stat. 1873, 1873–74; *see also* H.R. REP. NO. 1476, 94th Cong., 2d Sess. 116 (1976), *reprinted in* 1976 U.S.C.C.A.N. 5731, 5731 (discussing issues regarding computers and copyrights). These issues had not been addressed in the 1974 Copyright Act. Pub. L. No. 94-553, § 117, 90 Stat. 2565 (1976), *repealed by* Computer Software Protection Act, Pub. L. No. 96-517, § 117, 94 Stat. 3028 (1980) (codified at 17 U.S.C. § 117 (1988)).

[162] *See* Act of Dec. 31, 1974 § 201.

[163] *Id.* § 201(a)–(b).

[164] *See* NAT'L COMM'N ON NEW TECH. USES OF COPYRIGHTED WORKS, FINAL REPORT ON NEW TECHNOLOGICAL USES OF COPYRIGHTED WORKS 44 (1979).

[165] *See id.*

[166] *Id*. at 1.

the computer."[167] Former CONTU Commissioner Arthur Miller explained that "CONTU did not attempt to determine whether a computer work generated with little or no human involvement is copyrightable."[168] Congress subsequently codified CONTU's recommendations.[169]

Nearly a decade later, in 1986, advances in computing prompted the U.S. Congress's Office of Technology Assessment ("OTA") to issue a report arguing that CONTU's approach was too simplistic and computer programs were more than "inert tools of creation."[170] The OTA report contended that, in many cases, computers were at least "co-creators."[171] The OTA did not dispute that computer-generated works should be copyrightable, but it did foresee problems with determining authorship.[172]

The 2014 iteration of the Human Authorship Requirement was partially the result of a prominent public discourse about nonhuman authorship stemming from the "Monkey Selfies."[173] The Monkey Selfies are a series of images that a Celebes crested macaque took of itself in 2011 using equipment belonging to the nature photographer David Slater.[174] Mr. Slater reports that he staged the photographs by setting up a camera on a tripod and leaving a remote trigger for the macaque to use.[175] He subsequently licensed the photographs,

[167] *Id*. at 45. This rule is largely similar in British law: "In the case of a literary, dramatic, musical or artistic work which is computer-generated, the author shall be taken to be the person by whom the arrangements necessary for the creation of the work are undertaken." Copyright, Designs and Patent Act 1988, c. 48 § 9(3) (UK). "'Computer-generated,' in relation to a work, means that the work is generated by computer in circumstances such that there is no human author of the work." *Id.* § 178.

[168] Miller, *supra* note 146, at 1070. Professor Miller continued to argue in 1993 that "computer science does not appear to have reached a point at which a machine can be considered so 'intelligent' that it truly is creating a copyrightable work." *Id*. at 1073. Rather, "for the foreseeable future, the copyrightability of otherwise eligible computer-generated works can be sustained because of the significant human element in their creation, even though there may be some difficulty is assigning authorship." *Id.*

[169] *See* 17 U.S.C. § 117.

[170] *See* U.S. CONGRESS, OFFICE OF TECH. ASSESSMENT, INTELLECTUAL PROPERTY RIGHTS IN AN AGE OF ELECTRONICS AND INFORMATION 70–73 (1986). As stated by the OTA:

> Courts will then be left with little guidance, and even less expertise, to solve these highly complex conceptual and technological issues. . . . [E]ither the legislature or the courts will have to confront some questions that will be very difficult to resolve under the present system. These include: . . . What of originality in works that are predominately automated? Who is the author? Providing answers to these questions will become more urgent as creative activities continue to fuse with machine intelligence.

Id. at 71–73.

[171] *Id*. at 72.

[172] *Id*. at 73.

[173] *See* Naruto v. Slater, No. 3:2015-cv-04324, 2016 WL 362231, *1 (N.D. Cal. Jan. 23, 2016).

[174] *Id*. at *1.

[175] *See Sulawesi Macaques*, DJS PHOTOGRAPHY, http://www.djsphotography.co.uk/original_story.html [https://perma.cc/H93K-8CB9] (last visited Jan. 26, 2016) (showing Mr. Slater's photographs and providing an overview of how he staged them). The claim by Mr. Slater that he engineered the shoot is controversial based on his earlier reports of the event in question. *See* Mike Masnick,

claiming he owned their copyright.[176] Other parties then reposted the photographs without his permission and over his objections, asserting that he could not copyright the images without having taken them directly.[177] On December 22, 2014, the Copyright Office published its Human Authorship Requirement, which specifically lists the example of a photograph taken by a monkey as something not protectable.[178]

In September 2015, People for the Ethical Treatment of Animals ("PETA") filed a copyright infringement suit against Mr. Slater on behalf of Naruto, the monkey it purports took the Monkey Selfies, asserting that Naruto was entitled to copyright ownership.[179] On January 28, 2016, U.S. District Judge William H. Orrick III dismissed PETA's lawsuit against Slater.[180] Judge Orrick reasoned that the issue of the ability for animals to obtain a copyright is "an issue for Congress and the President."[181] The case is currently under appeal in the Ninth Circuit.[182]

B. Computers Should Qualify as Legal Inventors

1. Arguments Supporting Computer Inventors

Preventing patents on computational inventions by prohibiting computer inventors, or allowing such patents only by permitting humans who have discovered the work of creative machines to be inventors, is not an optimal system. In the latter case, AI may be functioning more or less independently, and it is only sometimes the case that substantial insight is needed to identify and understand a computational invention. Imagine that Person *C* instructs their AI to develop an iPhone battery with twice the standard battery life and gives it some publically available battery schematics. The AI could produce results in the form of a report titled "Design for Improved iPhone Battery"—complete with schematics and potentially even pre-formatted as a patent application. It seems inefficient and unfair to reward *C* for recognizing the AI's invention when *C* has not contributed significantly to the innovative process.

Photographer David Slater Claims That Because He Thought Monkeys Might Take Pictures, Copyright Is His, TECHDIRT (July 15, 2011), https://www.techdirt.com/articles/20110714/16440915097/photographer-david-slater-claims-that-because-he-thought-monkeys-might-take-pictures-copyright-is-his.shtml [https://perma.cc/MA7S-PFJ9].

[176] *See Naruto*, 2016 WL 362231, at *1.

[177] *See* Masnick, *supra* note 175.

[178] COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES, *supra* note 14, § 313.2.

[179] *See Naruto*, 2016 WL 362231, at *1.

[180] *Id*.

[181] *See id.*; Beth Winegarner, *'Monkey Selfie' Judge Says Animals Can't Sue Over Copyright*, LAW 360 (Jan. 6, 2016), https://www.cooley.com/files/'MonkeySelfie'JudgeSaysAnimalsCan'tSueOverCopyright.pdf [https://perma.cc/2CUG-2JDT].

[182] *See generally* Opening Brief of Plaintiff-Appellant, Naruto v. Slater, No. 3:15-cv-04324 (9th Cir. July 28, 2016) (arguing for the appeal of the district court's decision).

Such a system might also create logistical problems. If *C* had created an improved iPhone battery as a human inventor, *C* would be its inventor regardless of whether anyone subsequently understood or recognized the invention. If *C* instructed *C*'s AI to develop an improved iPhone battery, the first person to notice and appreciate the AI's result could become its inventor (and prevent *C* from being an inventor). One could imagine this creating a host of problems: the first person to recognize a patentable result might be an intern at a large research corporation or a visitor in someone's home. A large number of individuals might also concurrently recognize a result if access to an AI is widespread.

More ambitiously, treating computational inventions as patentable and recognizing creative computers as inventors would be consistent with the Constitutional rationale for patent protection.[183] It would encourage innovation under an incentive theory. Patents on computational inventions would have substantial value independent of the value of creative computers; allowing computers to be listed as inventors would reward human creative activity upstream from the computer's inventive act. Although AI would not be motivated to invent by the prospect of a patent, it would motivate computer scientists to develop creative machines. Financial incentives may be particularly important for the development of creative computers because producing such software is resource intensive.[184] Though the impetus to develop creative AI might still exist if computational inventions were considered patentable but computers could not be inventors, the incentives would be weaker owing to the logistical, fairness, and efficiency problems such a situation would create.

There are other benefits to patents beyond providing an *ex ante* innovation incentive. Permitting computer inventors and patents on computational inventions might also promote disclosure and commercialization.[185] Without the ability to obtain patent protection, owners of creative computers might choose to protect patentable inventions as trade secrets without any public dis-

---

[183] *See* U.S. CONST. art. I, § 8, cl. 8. Among those addressing the patentability implications of computational invention, Ralph Clifford has argued that works generated autonomously by computers should remain in the public domain unless AI develops a consciousness that allows it to respond to the Copyright Act's incentives. *See* Clifford, *supra* note 4, at 1702–03; *see also* Liza Vertinsky & Todd M. Rice, *Thinking About Thinking Machines: Implications of Machine Inventors for Patent Law*, 8 B.U. J. SCI. & TECH. L. 574, 581 (2002). Colin R. Davies has argued more recently that a computer should be given legal recognition as an individual under UK law to allow proper attribution of authorship and to allow respective claims to be negotiated through contract. *See generally* Colin R. Davies, *An Evolutionary Step in Intellectual Property Rights—Artificial Intelligence and Intellectual Property*, 27 COMPUT. L. & SEC. REV. 601 (2011).

[184] *See, e.g.*, Ferrucci et al., *supra* note 82, at 59 (stating that Watson's creation required "three years of intense research and development by a core team of about 20 researchers").

[185] *See, e.g.*, *Innovation's Golden Goose*, THE ECONOMIST, Dec. 12, 2002, at 3 (discussing the increase in innovation after the Bayh-Dole Act of 1980 because the legislation providing inventors an incentive to disclose and commercialize their ideas).

closure.[186] Likewise, businesses might be unable to develop patentable inventions into commercial products without patent protection.[187] In the pharmaceutical and biotechnology industries, for example, the vast majority of expense in commercializing a new product is incurred after the product is invented during the clinical testing process required to obtain regulatory approval for marketing.[188]

2. Arguments Against Computer Inventors

Those arguments reflect the dominant narrative justifying the grant of intellectual property protection.[189] That account, however, has been criticized, particularly by academics.[190] Patents result in significant social costs by establishing monopolies.[191] Patents also can stifle entry by new ventures by creating barriers to subsequent research.[192] Whether the benefit of patents as an innovation incentive outweighs their anti-competitive costs, or for that matter, whether patents even have a net positive effect on innovation, likely varies between industries, areas of scientific research, and inventive entities.[193]

---

[186] *See, e.g.*, Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 535 U.S. 722, 736 (2002) ("[E]xclusive patent rights are given in exchange for disclosing the invention to the public.").

[187] Commercialization theory holds that patents are important in providing incentives for investment in increasing the value of a patented technology. *See* Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265, 276–77 (1977).

[188] *See* TUFTS CTR. FOR THE STUDY OF DRUG DEV., *Briefing: Cost of Developing a New Drug* (Nov. 18, 2014), http://csdd.tufts.edu/files/uploads/Tufts_CSDD_briefing_on_RD_cost_study_-_Nov_18,_2014..pdf (estimating that pre-human expenditures are 30.8% of costs per approved compound, and estimating average pre-tax industry cost per new prescription drug approval [inclusive of failures and capital costs] is $2.55 billion). The cost of new prescription drug approval is hotly contested. *See, e.g.*, Roger Collier, *Drug Development Cost Estimates Hard to Swallow*, 180 CANADIAN MED. ASS'N J. 279, 279 (2009).

[189] *See* Jeanne C. Fromer, *Expressive Incentive in Intellectual Property*, 98 VA. L. REV. 1745, 1746 (2012).

[190] *See generally, e.g.*, Frederick M. Abbott, *The Doha Declaration on the TRIPS Agreement and Public Health: Lighting a Dark Corner at the WTO*, 5 J. INT'L ECON L. 469 (2002) (discussing problems with a pure incentive theory for patents in the medicines context).

[191] *See* Daniel J. Hemel & Lisa Larrimore Ouellette, *Beyond the Patents–Prizes Debate*, 92 TEX. L. REV. 303, 314–15 (2013) (discussing the deadweight loss of monopoly).

[192] *See* Lisa Larrimore Ouellette, *Access to Bio-Knowledge: From Gene Patents to Biomedical Materials*, 2010 STAN. TECH. L. REV. 48, 3 at n. 1 (considering effects of patents on entry to the biomedical products market); Arti Kaur Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77, 133 (1999); *see also* Bhaven Sampat & Heidi L. Williams, How Do Patents Affect Follow-on Innovation? Evidence from the Human Genome 15 (Oct. 13, 2015) (unpublished manuscript), *available at* http://economics.mit.edu/files/10782 [https://perma.cc/5K7N-89C4] (discussing patents to entry created by patents).

[193] As discussed above, the need for patent incentives is particularly compelling in the pharmaceutical context where large investments in clinical research over several years are typically needed to commercialize products that often are inexpensive for competitors to replicate. *See* Benjamin N. Roin, *Unpatentable Drugs and the Standards of Patentability*, 87 TEX. L. REV. 503, 545–47 (2009).

For instance, commentators such as Judge Richard Posner have argued that patents may not be needed to incentivize R&D in the software industry.[194] Software innovation is often relatively inexpensive, incremental, quickly superseded, produced without patent incentives, protected by other forms of intellectual property, and associated with a significant first mover advantage.[195] Likewise, patents may be unnecessary to spur innovation in university settings where inventors are motivated to publish their results for prestige and the prospect of academic advancement.[196]

Computational inventions may develop due to non-patent incentives. Software developers have all sorts of non-economic motivations to build creative computers: for example, to enhance their reputations, satisfy scientific curiosity, or collaborate with peers.[197] Business ventures might find the value of computational inventions exceeds the cost of developing creative computers even in the absence of patent protection. Of course, computational invention patents may not be an all-or-nothing proposition; they may further encourage activities that would have otherwise occurred on a smaller scale over a longer timeframe. If patents are not needed to incentivize the development of creative computers, it may be justifiable to treat computational inventions as unpatentable and failing to recognize computer inventors. Yet, whether patents produce a net benefit as an empirical matter is difficult to determine *a priori*. Even though individuals and businesses do not always behave as rational economic actors, in the aggregate, it is likely that providing additional financial incentives to spur the development of creative computers will produce a net benefit.[198]

Patents for computational inventions might also be opposed on the grounds that they would chill future human innovation, reward human inven-

---

[194] *See* WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 312–13 (2003).

[195] *See id.*; *see also* Eric Goldman, *The Problems with Software Patents*, FORBES (Nov. 28, 2012), http://www.forbes.com/sites/ericgoldman/2012/11/28/the-problems-with-software-patents/#234ba3d66545 [https://web.archive.org/web/20160412114510/http://www.forbes.com/sites/ericgoldman/2012/11/28/the-problems-with-software-patents/#41a0c38b2a70] (discussing in a three-part series why patents may be unnecessary for software, challenges to fixing the problems, and exploring possible fixes).

[196] *See* Mark A. Lemley, *Are Universities Patent Trolls?*, 18 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 611, 621 (2008).

[197] *See* YOCHAI BENKLER, THE WEALTH OF NETWORKS 65 (2006). Further, behavior law and economics posits that actual people do not act in accordance with standard economic principles because they have limited rationality, willpower, and self-interest. *See* Christine Jolls, Cass R. Sunstein, & Richard Thaler, *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471, 1476 (1998).

[198] *See, e.g.*, GARY S. BECKER, THE ECONOMIC APPROACH TO HUMAN BEHAVIOR 14 (1978) ("[A]ll human behavior can be viewed as involving participants who [1] maximize their utility [2] from a stable set of preferences and [3] accumulate an optimal amount of information and other inputs in a variety of markets.").

tors who failed to contribute to the inventive process, and result in further consolidation of intellectual property in the hands of big business (assuming that businesses such as IBM will be the most likely to own creative computers).[199]

Other non-utilitarian patent policies do not appear to support computer inventorship. For example, courts have justified granting patent monopolies on the basis of Labor Theory, which holds that a person has a natural right to the fruits of their work.[200] Labor Theory may support giving a patent to someone who has worked for years to invent a new device so that they can profit from their invention, but it does not apply to computers because computers cannot own property. All computer work is appropriated. Similarly, Personality Theory, which holds that innovation is performed to fulfill a human need, would not apply to AI.[201] Creative computers invent because they are instructed to invent, and a machine would not be offended by the manner in which its inventions were used. AI might even be a concerning recipient for inventorship under Social Planning Theory, which holds that patent rights should be utilized to promote cultural goals.[202] An AI could develop immoral new technologies.[203] Submissions, however, are no longer rejected by the Patent Office for being "deceitful" or "immoral," and, to the extent this is a concern, there would be opportunities for a person to judge the morality of an application before it is granted.[204]

---

[199] *See generally* Jamie Carter, *The Most Powerful Supercomputers in the World—and What They Do*, TECHRADAR (Dec. 13, 2014), http://www.techradar.com/us/news/computing/the-most-powerful-supercomputers-in-the-world-and-what-they-do-1276865 [https://perma.cc/AZ94-H3B2] (noting that most advanced computer systems are owned by governments and large businesses).

[200] *See* William Fisher, *Theories of Intellectual Property*, *in* NEW ESSAYS IN THE LEGAL AND POLITICAL THEORY OF PROPERTY 173–74 (Stephen Munzer ed., 2001).

[201] Tom G. Palmer, *Are Patents and Copyrights Morally Justified? The Philosophy of Property Rights and Ideal Object*s, 13 HARV. J.L. & PUB. POL'Y 817, 835–36 (1990).

[202] Mohammad Amin Naser, *Computer Software: Copyrights v. Patents*, 8 LOY. L. & TECH. ANN. 37, 41–42 (2009).

[203] Beneficial utility was once required for patent grant such that "deceitful" or "immoral" inventions would not qualify. In 1999, The United States Court of Appeals for the Federal Circuit in *Juicy Whip, Inc. v. Orange Bang, Inc.*, stated:

> [Y]ears ago courts invalidated patents on gambling devices on the ground that they were immoral, . . . but that is no longer the law . . . . "Congress never intended that the patent laws should displace the police powers of the States, meaning by that term those powers by which the health, good order, peace and general welfare of the community are promoted". . . . [W]e find no basis in section 101 to hold that inventions can be ruled unpatentable for lack of utility simply because they have the capacity to fool some members of the public.

185 F.3d 1364, 1367–68 (Fed. Cir. 1999) (quoting Webber v. Virginia, 103 U.S. 344, 347–48 (1880))

[204] *See id. See generally* Cynthia M. Ho, *Splicing Morality and Patent Law: Issues Arising from Mixing Mice and Men*, 2 WASH. U. J.L. & POL'Y 247, 247–85 (2000) (discussing Social Planning theory).

Ultimately, despite concerns, computer inventorship remains a desirable outcome. The financial motivation it will provide to build creative computers is likely to result in a net increase in the number of patentable inventions produced. Particularly, while quantitative evidence is lacking about the effects of computational invention patents, courts and policy makers should be guided first and foremost by the explicit constitutional rationale for granting patents.[205] Further, allowing patents on computational inventions as well as computer inventors would do away with what is essentially a legal fiction—the idea that only a human can be the inventor of the autonomous output of a creative computer—resulting in fairer and more effective incentives.

C. It Does Not Matter Whether Computers Think

1. The Questionable Mental Act Requirement

The judicial doctrine that invention involves a mental act should not prevent computer inventorship. The Patent Act does not mention a mental act, and courts have discussed mental activity largely from the standpoint of determining when an invention is actually made not whether it is inventive. In any case, whether or not creative computers "think" or have something analogous to consciousness should be irrelevant with regards to inventorship criteria.[206]

To begin, the precise nature of a "mental act requirement" is unclear. Courts associating inventive activity with cognition have not been using terms precisely or meaningfully in the context of computational inventions. It is unclear whether computers would have to engage in a process that results in creative output—which they do—or whether, and to what extent, they would need to mimic human thought. If the latter, it is unclear what the purpose of such a requirement would be except to exclude nonhumans (for which a convoluted test is unnecessary). Dr. Thaler has argued eloquently that the Creativity Machine closely imitates the architecture of the human brain.[207] Should that mean that the Creativity Machine's inventions should receive patents while Watson's do not? There is a slippery slope in determining what constitutes a "thinking" computer system even leaving aside deficits in our understanding of the structure and function of the human brain. Perhaps the Creativity Machine still is not engaging in mental activity—would a computer scientist have to design a completely digitized version of the human brain? Even if designing a completely digitized version of the human brain was possible, it might not be the

---

[205] *See* United States v. Line Material Co., 333 U.S. 287, 316 (1948) (Douglas, J., concurring) (noting "the reward to inventors is wholly secondary" to the reward to society); *see also* THE FEDERALIST NO. 43 (James Madison) (stating that social benefit arises from patents to inventors).

[206] Though, it is surely a fascinating topic deserving of its own treatise.

[207] Thaler, *Synaptic Perturbation and Consciousness*, *supra* note 29.

most effective way to structure a creative computer.[208] On top of that, it would be difficult or impossible for the Patent Office and the courts to distinguish between different computers' architectures.

2. The Turing Test and a Functionalist Approach

The problem of speaking precisely about thought with regards to computers was identified by Alan Turing, one of the founders of computer science, who in 1950 considered the question, "Can machines think?"[209] He found the question to be ambiguous, and the term "think" to be unscientific in its colloquial usage.[210] Turing decided the better question to address was whether an individual could tell the difference between responses from a computer and an individual; rather than asking whether machines "think," he asked whether machines could perform in the same manner as thinking entities.[211] Dr. Turing referred to his test as the "Imitation Game" though it has come to be known as the "Turing test."[212]

Although the Turing test has been the subject of criticism by some computer scientists, Turing's analysis from more than sixty years ago demonstrates that a mental act requirement would be ambiguous, challenging to administer, and of uncertain utility.[213] Incidentally, it is noteworthy that the Patent Office administers a sort of Turing test, which creative computers have successfully passed. The Patent Office receives descriptions of inventions then judges whether they are nonobvious—which is a measure of creativity and ingenuity.[214] In the case of the Invention Machine's Patent, it was already noted that "January 25, 2005 looms large in the history of computer science as the day that genetic programming passed its first real Turing test: The examiner had no idea that he was looking at the intellectual property of a computer."[215] In an-

---

[208] This is analogous to one of the criticisms of the Turing test. Namely, that mimicking human responses may not be the best test of intelligence given that not all human responses are intelligent. *See* Editorial, *Artificial Stupidity*, THE ECONOMIST, Aug. 1, 1992, at 14.

[209] Turing, *Computing Machinery and Intelligence*, *supra* note 131, at 433. "Nobody so far has been able to give a precise, verifiable definition of what general intelligence or thinking is. The only definition I know that, though limited, can be practically used is Alan Turing's. With his test, Turing provided an operational definition of a specific form of thinking—human intelligence." Tomaso Poggio, *"Turing+" Questions*, *in* WHAT TO THINK ABOUT MACHINES THAT THINK 48 (John Brockman ed., 2015).

[210] *See* Turing, *Computing Machinery and Intelligence*, *supra* note 131, at 433.

[211] *See id.* at 433–34.

[212] *See id.* at 433.

[213] *See, e.g.*, Jose Hernandez-Orallo, *Beyond the Turing Test*, 9 J. LOGIC LANGUAGE & INFO. 447, 447 (2000).

[214] *See* Koza et al., *Evolving Inventions*, *supra* note 49, at 59. The Patent Office "receives written descriptions of inventions and then judges whether they are nonobvious," which is a measure of creativity and ingenuity. *See id.*

[215] Keats, *John Koza Has Built an Invention Machine*, *supra* note 57.

other sense, GP had already also passed the test by independently recreating previously patented inventions: because the original human invention received a patent, the AI's invention should have received a patent as well, leaving aside that the original patent would be prior art not relied upon by the GP.[216]

3. The Invention Matters, Not the Inventor's Mental Process

The primary reason a mental act requirement should not prevent computer inventorship is that the patent system should be indifferent to the means by which invention comes about.

Congress came to this conclusion in 1952 when it abolished the Flash of Genius doctrine.[217] That doctrine had been used by the Federal Courts as a test for patentability for over a decade.[218] It held that in order to be patentable, a new device, "however useful it may be, must reveal the flash of creative genius, not merely the skill of the calling."[219] The doctrine was interpreted to mean that an invention must come into the mind of an inventor in a "flash of genius" rather than as a "result of long toil and experimentation."[220] As a commentator at the time noted, "the standard of patentable invention represented by [the Flash of Genius doctrine] is apparently based upon the nature of the mental processes of the patentee-inventor by which he achieved the advancement in the art claimed in his patent, rather than solely upon the objective nature of the advancement itself."[221]

The Flash of Genius test was an unhelpful doctrine because it was vague, difficult for lower courts to interpret, involved judges making subjective decisions about a patentee's state of mind, and made it substantially more difficult

[216] *See id.*

[217] *See* 35 U.S.C. § 103 (2012).

[218] *See, e.g.*, Hamilton Standard Propeller Co. v. Fay-Egan Mfg. Co., 101 F.2d 614, 617 (6th Cir. 1939) ("The patentee did not display any flash of genius, inspiration or imagination . . . ."). The doctrine was formalized by the Supreme Court in 1941 in *Cuno Engineering Corp. v. Automatic Devices Corp.* 314 U.S. 84, 91 (1941). It was reaffirmed by the Court in 1950 in *Great Atlantic & Pacific Tea Co. v. Supermarket Equipment Corp.*, 340 U.S. 147, 154 (1950) (Douglas, J., concurring).

[219] *Cuno Eng'g Corp.*, 314 U.S. at 91.

[220] The Supreme Court later claimed the "Flash of Creative Genius" language was just a rhetorical embellishment and that requirement concerned the device not the manner of invention. Graham v. John Deere Co. of Kan. City, 383 U.S. 1, 15 n.7, 16 n.8 (1966). That was not, however, how the test was interpreted. *See* P.J. Federico, *Origins of Section 103*, 5 APLA Q.J. 87, 97 n.5 (1977) (noting the test led to a higher standard of invention in the lower courts). When Congress abolished the test, Congress noted it should be immaterial whether invention was made "from long toil and experimentation or from a flash of genius." 35 U.S.C. § 103. Further, the Court stated in 1966 in *Graham* that "[t]he second sentence states that patentability as to this requirement is not to be negatived by the manner in which the invention was made, that is, it is immaterial whether it resulted from long toil and experimentation or from a flash of genius." *Graham*, 383 U.S. at 16 n.8.

[221] *The "Flash of Genius" Standard of Patentable Invention*, *supra* note 18, at 87.

to obtain a patent.[222] The test was part of a general hostility toward patents exhibited by mid-twentieth century courts, a hostility that caused United States Supreme Court Justice Robert Jackson to note in a dissent that "the only patent that is valid is one which this Court has not been able to get its hands on."[223]

Criticism of this state of affairs led President Roosevelt to establish a National Patent Planning Commission to study the patent system and to make recommendations for its improvement.[224] In 1943, the Commission reported with regard to the Flash of Genius doctrine that "patentability shall be determined objectively by the nature of the contribution to the advancement of the art, and not subjectively by the nature of the process by which the invention may have been accomplished."[225] Adopting this recommendation, the Patent Act of 1952 legislatively disavowed the Flash of Genius test.[226] In the same manner, patentability of computational inventions should be based on the inventiveness of a computer's output rather than on a clumsy anthropomorphism because, like Turing, patent law should be interested in a functionalist solution.

4. A Biological Requirement Would Be a Poor Test

Incidentally, even a requirement for biological intelligence might be a bad way to distinguish between computer and human inventors. Although functioning biological computers do not yet exist, all of the necessary building blocks have been created.[227] In 2013, a team of Stanford University engineers created

---

[222] *See* DePaul College of Law, *Patent Law—"Flash of Genius" Test for Invention Rejected*, 5 DEPAUL L. REV. 144, 146 (1955); Stephen G. Kalinchak, *Obviousness and the Doctrine of Equivalents in Patent Law: Striving for Objective Criteria*, 43 CATH. U. L. REV. 577, 586 (1994).

[223] Jungersen v. Ostby & Barton Co., 335 U.S. 560, 572 (1949) (Jackson, J., dissenting).

[224] *See* William Jarratt, *U.S. National Patent Planning Commission*, 153 NATURE 12, 14 (1944).

[225] *The "Flash of Genius" Standard of Patentable Invention*, *supra* note 18, at 85 (internal quotation marks omitted).

[226] *See* 35 U.S.C. § 103 (2012). Further, in *Graham*, the Supreme Court noted that "[i]t . . . seems apparent that Congress intended by the last sentence of § 103 to abolish the test it believed this Court announced in the controversial phrase 'flash of creative genius,' used in *Cuno Engineering*." *Graham*, 383 U.S. at 15.

[227] *See* Sebastian Anthony, *Stanford Creates Biological Transistors, the Final Step Towards Computers Inside Living Cells*, EXTREMETECH (Mar. 29, 2013), http://www.extremetech.com/extreme/152074-stanford-creates-biological-transistors-the-final-step-towards-computers-inside-living-cells [https://perma.cc/ENX4-WZKA] (noting that, in addition to biological transistors, a method for data storage and a means of connecting transcriptors with memory would be necessary to create a biological computer and stating that "[f]ortunately, as we've covered a few times before, numerous research groups have successfully stored data in DNA—and Stanford has already developed an ingenious method of using the M13 virus to transmit strands of DNA between cells"); *see also* Monica E. Ortiz & Drew Endy, *Engineered Cell-Cell Communication via DNA Messaging*, J. BIOLOGICAL ENGINEERING (Dec. 1, 2012), https://jbioleng.biomedcentral.com/articles/10.1186/1754-1611-6-16 [https://perma.cc/6BWZ-GUUP]; Katherine Deria, *Biological Supercomputer Can Solve Complex Problems Using Less* Energy, TECH TIMES (Feb. 27, 2016), http://www.techtimes.com/articles/137017/20160227/biological-supercomputer-can-solve-complex-problems-using- less-energy.htm [https://perma.cc/A75T-3TVV] (describing a new biological supercomputer model powered by a biochemical that facilitates energy transfer among cells).

a biological version of an electrical transistor. Mechanical computers use numerous silicon transistors to control the flow of electrons along a circuit to create binary code.[228] The Stanford group created a biological version with the same functionality by using enzymes to control the flow of RNA proteins along a strand of DNA.[229] Envisioning a not-too-distant future in which computers can be entirely biological, there seems to be no principled reason why a biological, but not a mechanical version, of Watson should qualify as an inventor. In the event that policymakers decide computers should not be inventors, a rule explicitly barring nonhuman inventorship would be a better way to achieve that result.

D. Computer Inventors Are Permitted Under a Dynamic Interpretation of Current Law

Whether a computer can be an inventor in a constitutional sense is a question of first impression. If creative computers should be inventors, as this Article has argued, then a dynamic interpretation of the law should allow computer inventorship.[230] Such an approach would be consistent with the Founders' intent in enacting the Patent and Copyright Clause, and it would interpret the Patent Act to further that purpose.[231] Nor would such an interpretation run afoul of the chief objection to dynamic statutory interpretation, namely that it interferes with reliance and predictability and the ability of citizens "to be able to read the statute books and know their rights and duties."[232] That is because a dynamic interpretation would not upset an existing policy; permitting computer inventors would allow additional patent applications rather than retroactively invalidate previously granted patents, and there is naturally less reliance and predictability in patent law than in many other fields given that it is a highly dynamic subject area that struggles to adapt to constantly changing technologies.[233]

---

[228] *See* Anthony, *supra* note 227.

[229] *See id.*

[230] *See* William N. Eskridge, Jr. & Philip P. Frickey, *Statutory Interpretation as Practical Reasoning*, 42 STAN. L. REV. 321, 324 (1990).

[231] *See* HENRY M. HART, JR. & ALBERT M. SACKS, THE LEGAL PROCESS: BASIC PROBLEMS IN THE MAKING AND APPLICATION OF LAW 1124 (1994); *see also* Abbe R. Gluck, *The States as Laboratories of Statutory Interpretation: Methodological Consensus and the New Modified Textualism*, 119 YALE L.J. 1750, 1764 (2010) (noting that purposivists subscribe to dynamic methods of statutory interpretation).

[232] *See* Eskridge, Jr. & Frickey, *supra* note 230, at 340.

[233] *See* William C. Rooklidge & W. Gerard von Hoffmann, III, *Reduction to Practice, Experimental Use, and the "On Sale" and "Public Use" Bars to Patentability*, 63 ST. JOHN'S L. REV. 1, 49–50 (1988).

Other areas of patent law have been the subject of dynamic interpretation.[234] For example, in the landmark 1980 case of *Diamond v. Chakrabarty*, the Supreme Court was charged with deciding whether genetically modified organisms could be patented.[235] It held that a categorical rule denying patent protection for "inventions in areas not contemplated by Congress . . . would frustrate the purposes of the patent law."[236] The court noted that Congress chose expansive language to protect a broad range of patentable subject matter.[237]

Under that reasoning, computer inventorship should not be prohibited based on statutory text designed to favor individuals over corporations. It would be particularly unwise to prohibit computer inventors on the basis of literal interpretations of texts written when computational inventions were unforeseeable. If computer inventorship is to be prohibited, it should only be on the basis of sound public policy. Drawing another analogy from the copyright context, just as the terms "Writings" and "Authors" have been construed flexibly in interpreting the Patent and Copyright Clause, so too should the term "Inventors" be afforded the flexibility needed to effectuate constitutional purposes.[238] Computational inventions may even be especially deserving of protection because computational creativity may be the only means of achieving certain discoveries that require the use of tremendous amounts of data or that deviate from conventional design wisdom.[239]

III. IMPLICATIONS OF COMPUTER INVENTORSHIP

This Part finds that a computer's owner should be the default assignee of any invention because this is most consistent with the rules governing owner-

---

[234] The Supreme Court has called the section of the U.S. Code relating to patentable subject matter a "dynamic provision designed to encompass new and unforeseen inventions." J.E.M. AG Supply, Inc. v. Pioneer Hi-Bred Int'l, Inc., 534 U. S. 124, 135 (2001). The Court noted in *Bilski v. Kappos* that "it was once forcefully argued that until recent times, 'well- established principles of patent law probably would have prevented the issuance of a valid patent on almost any conceivable computer program.'" 561 U.S. 593, 605 (2010) (quoting Diamond v. Diehr, 450 U.S 175, 195 (1981) (Stevens, J., dissenting)). The Court, however, went on to state that "this fact does not mean that unforeseen innovations such as computer programs are always unpatentable." *Id.* (citing *Diehr*, 450 U.S at 192–93 (Stevens, J., dissenting)).

[235] *See* Diamond v. Chakrabarty, 447 U. S. 303, 317 (1980).

[236] *Id*. at 315.

[237] *See id*. at 316.

[238] In 1973, the Supreme Court in *Goldstein v. California* noted that the terms "Writings" and "Authors," have "not been construed in their narrow literal sense but, rather, with the reach necessary to reflect the broad scope of constitutional principles." 412 U.S. 546, 561 (1973).

[239] *See* Jason D. Lohn, *Evolvable Systems for Space Application*, NASA (Nov. 24, 2003), http://www.genetic-programming.com/c2003jasonlohn20031124talk.pdf [https://perma.cc/BWC7-UPJK]; Adam Frank, *The Infinite Monkey Theorem Comes to Life*, NPR (Dec. 10, 2013), http://www.npr.org/blogs/13.7/2013/12/10/249726951/the-infinite-monkey-theorem-comes-to-life [https://perma.cc/PT5R-53GS].

ship of property and it would most incentivize innovation.[240] Additionally, this Part suggests that where a computer's owner, developer, and user are different entities, such parties could negotiate alternative arrangements by contract.[241] Computer ownership here generally refers to software ownership, although there may be instances in which it is difficult to distinguish between hardware and software, or even to identify a software "owner."[242] This Part also examines the phenomenon of automation and the displacement of human inventors by computers and finds that computational invention remains beneficial despite legitimate concerns.[243]

This Part concludes by finding that the arguments in support of computer inventorship apply with equal force to non-human authors.[244] Allowing animals to create copyrightable material would result in more socially valuable art by creating new incentives for people to facilitate animal creativity.[245] It would also provide incentives for environmental conservation.[246] Lastly, this Part examines some of the implications of computer inventorship for other areas of patent law.[247]

A. Computational Invention Ownership

1. Options for Default Assignment Rules

In the event that computers are recognized as patent inventors, there still remains the question of who would own these patents. Computers cannot own property, and it is safe to assume that "computer personhood" is not on the horizon.[248] This presents a number of options for patent ownership (assignment) such as a computer's owner (the person who owns the AI as a chattel), developer (the person who programmed the AI's software), or user (the person giving the AI tasks).[249] The developer, user, and owner may be the same person, or they may be different entities.

Ownership rights to computational inventions should vest in a computer's owner because it would be most consistent with the way personal property (in-

---

[240] *See infra* notes 240–312 and accompanying text.

[241] *See infra* notes 248–255 and accompanying text.

[242] *See generally* GOVERNMENT OFFICE FOR SCIENCE, *supra* note 20.

[243] *See infra* notes 256–278 and accompanying text.

[244] *See infra* notes 279–312 and accompanying text.

[245] *See infra* notes 279–287 and accompanying text.

[246] *See infra* notes 279–287 and accompanying text.

[247] *See infra* notes 288–313 and accompanying text.

[248] *See generally* Adam Winkler, *Corporate Personhood and the Rights of Corporate Speech*, 30 SEATTLE U. L. REV. 863, 863 (2007) (describing the phenomenon of "corporate personhood").

[249] There are other, less conventional, options. For instance, even if legally listed as an inventor, it might be the case that no one could own a computer's invention and that computational inventions would automatically become part of the public domain. New legislation could also establish that ownership rights to computational inventions automatically vest in a government agency.

cluding both computers and patents) is treated in the United States and it would most incentivize computational invention.[250] Assignment of computational inventions to a computer's owner could be taken as a starting point although parties would be able to contract around this default, and as computational inventions become more common, negotiations over these inventions may become a standard part of contract negotiations.[251]

2. Owner vs. User Assignment

To see why it would be problematic to have patent ownership rights vest in a computer's user, consider the fact that IBM has made Watson available to numerous developers without transferring Watson's ownership.[252] To the extent that Watson creates patentable results as a product of its interactions with users, promoting user access should result in more innovation.

There is theoretically no limit to the number of users that Watson, as a cloneable software program, could interact with at once. If Watson invents while under the control of a non-IBM user, and the "default rule" assigns the invention to the user, IBM might be encouraged to restrict user access; in contrast, assigning the invention to IBM would be expected to motivate IBM to further promote access. If IBM and a user were negotiating for a license to Watson, the default rule might result in a user paying IBM an additional fee for the ability to patent results or receiving a discount by sticking with the default. It may also be the case that Watson co-invents along with a user; in which case, a system of default assignment to a computer's owner would result in both IBM and the user co-owning the resulting patent. Where creative computers are not owned by large enterprises with sophisticated attorneys, it is more likely the default rule will govern the final outcome.[253]

---

[250] *See* Annemarie Bridy, *Coding Creativity: Copyright and the Artificially Intelligent Author*, 2012 STAN. TECH. L. REV. 1, 1–28 (arguing that "AI authorship is readily assimilable to the current copyright framework through the work made for hire doctrine, which is a mechanism for vesting copyright directly in a legal person who is acknowledged *not* to be the author-in-fact of the work in question").

[251] *See generally* Ian Ayres & Robert Gertner, *Filling Gaps in Incomplete Contracts: An Economic Theory of Default Rules*, 99 YALE L.J. 87 (1990) (discussing default rules and how they are formed in the context of contract law).

[252] Bruce Upbin, *IBM Opens Up Its Watson Cognitive Computer for Developers Everywhere*, FORBES (Nov. 14, 2013), http://www.forbes.com/sites/bruceupbin/2013/11/14/ibm-opens-up-watson-as-a-web-service/ [https://web.archive.org/web/20160310124933/http://www.forbes.com/sites/bruceupbin/2013/11/14/ibm-opens-up-watson-as-a-web-service/#1ccc9051d0ee].

[253] *See, e.g.*, Daniel D. Barnhizer, *Power, Inequality and the Bargain: The Role of Bargaining Power in the Law of Contract—Symposium Introduction*, 2006 MICH. ST. L. REV. 841, 842 (describing various approaches to dealing with bargaining power asymmetries).

3. Owner vs. Developer Assignment

Likewise, patent ownership rights should vest in a computer's owner rather than its developer. Owner assignment would provide a direct economic incentive for developers in the form of increased consumer demand for creative computers. Having assignment default to developers would interfere with the transfer of personal property in the form of computers, and it would be logistically challenging for developers to monitor computational inventions made by machines they no longer own.

In some instances, however, owner assignment of intellectual property (IP) rights might produce unfair results. In the movie *Her*, the protagonist (who is a writer) purchases an AI named Samantha that organizes his existing writings into a book, which it then submits to be published.[254] It is possible that Samantha would own the copyright in the selection and arrangement of his writings and would thus have a copyright interest in the book.[255] Here, owner assignment of intellectual property rights seems unappealing if there is a minimal role played by the consumer/owner. The consumer's role in the process might be limited to simply purchasing a creative computer and asking it to do something (where the owner is the user) or purchasing a computer and then licensing it to someone else to use creatively. Further, assigning computer inventions to owners might impede the development or sharing of creative machines because the machine developers might want to retain the rights to the computational inventions their computers produce.

These problems are more easily resolved than problems associated with assigning intellectual property rights to developers by default. Developers could either require owners to pay them the value of a creative machine, taking into account the likelihood of those machines engaging in computational invention, or avoid the problem by licensing rather than selling creative computers. In the case of licensing, the developer remains the owner, and the consumer is simply a user. One might imagine a creative computer, such as the AI in *Her*, coming with a license agreement under which consumers prospectively assign any inventions made by the system to the licensor.

This analysis also reveals an important reason why computational invention works best when the computer is the legal inventor. If computational inventions were treated as patentable but computers could not be inventors, then presumably the first person to recognize a computer's invention would be the legal inventor and patent owner. That means that the computer's user, rather than its developer or owner, would likely be the patentee as the person in a position to first recognize a computational invention. To the extent this is an un-

---

[254] HER (Annapurna Pictures 2013).

[255] *See* RONALD B. STANDLER, COPYRIGHT FOR COMPILATIONS IN THE USA 22 (2013).

desirable outcome, as this Article has argued, then the best solution is to permit computer inventorship.

In sum, assigning a computer's invention by default to the computer's owner seems the preferred outcome, and computer owners would still be free to negotiate alternate arrangements with developers and users by contract.

B. Coexistence and Competition

1. Computers and People Will Compete in Creative Fields

> *"IBM has bragged to the media that Watson's question-answering skills are good for more than annoying Alex Trebek. The company sees a future in which fields like medical diagnosis, business analytics, and tech support are automated by question-answering software like Watson. Just as factory jobs were eliminated in the 20th century by new assembly-line robots, [Watson's Jeopardy competitors] were the first knowledge-industry workers put out of work by the new generation of 'thinking' machines. 'Quiz show contestant' may be the first job made redundant by Watson, but I'm sure it won't be the last."*[256]

With the expansion of computers into creative domains previously occupied only by people, machines threaten to displace human inventors. To better understand this phenomenon, consider the following hypothetical example involving the field of antibody therapy.

Antibodies are small proteins made naturally by the immune system, primarily to identify and neutralize pathogens such as bacteria and viruses.[257] They are Y-shaped proteins that are largely similar to one another in structure although antibodies contain an extremely variable region which binds to target structures.[258] Differences in that region are the reason different antibodies bind to different targets—for example the reason why one antibody binds to a cancer cell while another binds to the common cold virus.[259] The body generates antibody diversity in part by harnessing the power of random gene recombinations and mutations (much as GP does), and then it selects for antibodies with a desired binding (much as GP does).[260] Following the discovery of antibody structure and the development of technologies to manufacture antibodies in the 1970s, human researchers began to create antibodies for diagnostic and thera-

[256] Ken Jennings, *My Puny Human Brain*, SLATE (Feb 16, 2011), http://primary.slate.com/articles/arts/culturebox/2011/02/my_puny_human_brain.html [https://perma.cc/BE9X-NUNX].

[257] *See* Janice M. Reichert, *Marketed Therapeutic Antibodies Compendium*, 4 MABS 413, 413 (2012).

[258] *See* Neil S. Lipman et al., *Monoclonal Versus Polyclonal Antibodies: Distinguishing Characteristics, Applications, and Information Resources*, 46 ILAR J. 258, 258 (2005).

[259] *See id.* at 258–59.

[260] *See id.* at 259.

peutic purposes.[261] Therapeutic antibodies can block cell functions, modulate signal pathways, and target cancer cells among other functions.[262] There are now dozens of artificially manufactured antibodies approved to treat a variety of medical conditions.[263]

One of the interesting things about antibodies from a computational invention perspective is that a finite number of antibodies exist. There are, at least, billions of possible antibodies, which is enough natural diversity for the human immune system to function and to keep human researchers active for the foreseeable future.[264] Even so, there are only so many possible combinations of amino acids (the building blocks of proteins) that the body can string together to generate an antibody.[265] It is not hard to imagine that, with enough computing power, an AI could sequence every possible antibody that could ever be created. Even if that was trillions of antibodies, the task would be relatively simple for a powerful enough computer but impossible for even the largest team of human researchers without computer assistance.

Generating the entire universe of antibody sequences would not reveal all of the possible functions of those antibodies; so, a computer's owner could not obtain patents for all of the sequences on this basis alone because usefulness (utility) of the invention must be disclosed in addition to the sequence itself.[266] The computer could, however, prevent any future patents on the structure of new antibodies (assuming the sequence data is considered an anticipatory disclosure).[267] If this occurred, a computer would have preempted human invention in an entire scientific field.[268]

2. Computers May Refocus Human Activity

In the hypothetical scenario above, society would gain access to all possible future knowledge about antibody structure at once rather than waiting decades or centuries for individuals to discover these sequences. Early access to antibody sequences could prove a tremendous boon to public health if it led to

---

[261] *See* Reichert, *Marketed Therapeutic Antibodies Compendium*, *supra* note 257, at 413.
[262] *See id.*
[263] *See id.*
[264] *See* Lipman, *supra* note 258, at 258.
[265] *See, e.g.*, U.S. Patent No. 8,008,449 (filed May 2, 2006) (disclosing antibodies to the protein Programmed Death 1 ("PD-1") by virtue of publishing their amino acid sequences).
[266] *See In re* Fisher, 421 F.3d 1365, 1370 (Fed. Cir. 2005).
[267] *See* MPEP, *supra* note 43, § 2131.
[268] Along similar lines, projects such as "All Prior Art" and "All the Claims" are attempting to use machines to create and publish vast amounts of information to prevent other parties from obtaining patents. *See* ALL PRIOR ART, allpriorart.com/about/ [https://perma.cc/3XJR-2FF5] (last visited Jul. 10, 2016); ALL THE CLAIMS, alltheclaims.com/about/ [https://perma.cc/QDE2-5J49] (last visited Jul. 10, 2016); *see also* Hattenbach & Glucoft, *supra* note 5, at 35–36 (describing the efforts of a company, Cloem, which is mechanically publishing possible patent claims to prevent others from obtaining patents).

the discovery of new drugs. Some antibody sequences might never be identified without creative computers.

Creative computers may simply refocus, rather than inhibit, human creativity. In the short term, scientists who were working on developing new antibody structures might shift to studying how the new antibodies work, or finding new medical applications for those antibodies, or perhaps move on to studying more complex proteins beyond the capability of AI to comprehensively sequence. For the foreseeable future, there will be plenty of room for human inventors—all with net gains to innovation.

Antibody therapies are just one example of how AI could preempt invention in a field. A sophisticated enough computer could do something similar in the field of genetic engineering by creating random sequences of DNA. Living organisms are a great deal more complex than antibodies, but the same fundamental principles would apply. Given enough computing power, an AI could model quintillions of different DNA sequences, inventing new life forms in the process. In fact, on a smaller scale, this is something GP already does.[269] Although results have been limited by the computationally intense nature of the process, that will change as computers continue to improve.[270] By creating novel DNA sequences, GP would be performing the same function as non-digital GP—natural evolution!

3. Dealing with Industry Consolidation

It will probably be the case that creative computers result in greater consolidation of intellectual property in the hands of large corporations such as IBM. Such businesses may be the most likely to own creative computers owing to their generally resource intense development.[271] As previously discussed, the benefits, however, may outweigh the costs of such an outcome. Imagine that Watson was the hypothetical AI that sequenced every conceivable antibody and, further, that Watson could analyze a human cancer and match it with an antibody from its library to effectively treat the cancer. Essentially, this could allow IBM to patent the cure for cancer.

Though this would be profoundly disruptive to the medical industry and might lead to market abuses, it is not a reason to bar computational invention. Society would obtain the cure for cancer, and IBM would obtain a twenty-year monopoly (the term of a patent) in return for publically disclosing the infor-

---

269 *See, e.g.*, Tim Stefanini, *The Genetic Coding of Behavioral Attributes in Cellular Automata*, *in* ARTIFICIAL LIFE AT STANFORD 172–80 (John R. Koza ed., 1994); W.B. Langdon & B.F. Buxton, *Genetic Programming for Mining DNA Chip Data from Cancer Patients*, 5 GENETIC PROGRAMMING AND EVOLVABLE MACHINES 251, 251 (2004).

270 *See* Stefanini, *supra* note 269, at 172–80.

271 *See* Carter, *supra* note 199 (noting that most advanced computer systems are owned by governments and large businesses).

mation a competitor would need to duplicate Watson's invention.[272] In the absence of creative computers, such an invention might never come about.

To the extent that price gouging and supply shortages are a concern, protections are built into patent law to protect consumers against such problems.[273] For example, the government could exercise its march in rights or issue compulsory licenses.[274]

4. The Creative Singularity and Beyond

As creative computers become more and more sophisticated, at some point in the future, it is possible that they could have a very disruptive effect on human creativity. In recent years, a number of prominent scientists and entrepreneurs such as Bill Gates, Stephen Hawking, and Elon Musk have expressed concern about the "singularity"—a point in the future when machines outperform humans.[275] Likewise, a "creative singularity" in which computers overtake people as the primary source of innovation may be inevitable. Taken to its logical extreme and given that there is really no limit to the number of computers that could be built or their capabilities, it is not especially improbable to imagine that computers could eventually preempt much or all human inven-

---

[272] *See* MPEP, *supra* note 43, § 2164.

[273] See the case of Martin Shkreli, who has been pilloried for price gouging by drastically increasing the price of an old drug, Daraprim. *See* Andrew Pollack & Julie Creswell, *Martin Shkreli, the Mercurial Man Behind the Drug Price Increase That Went Viral*, N.Y. TIMES (Sept. 22, 2015), http://www.nytimes.com/2015/09/23/business/big-price-increase-for-an-old-drug-will-be-rolled-back-turing-chief-says.html?r_=0 [https://perma.cc/Q3Q3-95CS]. In this particular case, the monopoly was due to lack of competition, but the same economic principles apply to patent monopolies. *See* Ryan Abbott, *Balancing Access and Innovation in India's Shifting IP Regime, Remarks*, 35 WHITTIER L. REV. 341, 344 (2014) (discussing patent law protections against practices including "evergreening").

[274] *See, e.g.*, Abbott, *supra* note 273, at 345 (explaining India's issuance of a compulsory license).

[275] Of perhaps greater concern than automation displacing human workers, a number of prominent scientists are concerned about the implications of machines outperforming people. Professor Stephen Hawking has warned that self-improving computers could threaten the very existence of humanity. Rory Cellan-Jones, *Stephen Hawking Warns Artificial Intelligence Could End Mankind*, BBC (Dec. 2, 2014), http://www.bbc.com/news/technology-30290540 [https://perma.cc/2NWE-D8MB]. Elon Musk recently donated ten million dollars to an institute focused on threats posed by advances in AI. *See* Chris Isidore, *Elon Musk Gives $10M to Fight Killer Robots*, CNN MONEY (Jan. 16, 2015), http://money.cnn.com/2015/01/15/technology/musk-artificial-intelligence/ [https://perma.cc/6N3U-WTWF]; *see also* Dylan Love, *Scientists Are Afraid to Talk About the Robot Apocalypse, and That's a Problem*, BUSINESS INSIDER (July 18, 2014), http://www.businessinsider.com/robot-apocalypse-2014-7#ixzz3QQpLJ0Jj [https://perma.cc/AH5J-5G34] (noting that robots may pose a "real risk" to humanity); Kevin Rawlinson, *Microsoft's Bill Gates Insists AI Is a Threat*, BBC (Jan. 29, 2015), http://www.bbc.com/news/31047780 [https://perma.cc/9MXD-TQ68] (expressing Bill Gates's concerns about advanced AI). Concerns about the threat posed by advanced AI are nothing new. *See, e.g.*, Irving J. Good, *Speculations Concerning the First Ultraintelligent Machine*, 6 ADVANCES IN COMPUTERS 31, 31–88 (1966). As an aside, the date the patent for the Creativity Machine issued is the same date as "Judgment Day" from the original Terminator movie, August 29, 1997.

tion.[276] The future may involve iPads in place of fast food cashiers,[277] robots empathizing with hospital patients,[278] and AI responsible for research. For now, this is a distant possibility.

Moreover, patents on computational inventions would not prevent this outcome. If creative computers ever come to substantially outperform human inventors, they still will replace people—just without the ability to receive patents.

C. Lessons for Copyright Law

1. Promoting the Useful Arts and Environmental Conservation

The need for computer inventorship also explains why the Copyright Office's Human Authorship Requirement is misguided. Nonhumans should be allowed to qualify as authors because doing so would incentivize the creation of new and valuable creative output. In the case of the Monkey Selfies, Mr. Slater, a photographer familiar with macaques, reported that he carefully staged the environment in such a way that Naruto would be likely to take his own photograph.[279] If accurate, he probably did so in part due to an expectation of selling the resulting photographs.[280] Had Mr. Slater known in advance that the images would pass into the public domain, he might never have taken the photographs. Although an owner default assignment rule would give copyright ownership of the Monkey Selfies to Naruto's owner[281] rather than to Mr. Slater, he could have contracted with Naruto's owner to purchase or license the photographs. Certainly in the aggregate, fewer photographers will engage in such activities without the prospect of copyright protection, and although animal selfies are not the cure for cancer, they have societal value as does any other form of art.[282]

---

[276] *See* Brian Christian, *Mind vs. Machine*, THE ATLANTIC (Mar. 2011), http://www.theatlantic.com/magazine/archive/2011/03/mind-vs-machine/308386/ [https://perma.cc/7CMT-DAEZ].

[277] *See* Victoria Taft, *Protesters Aren't Going to Like How McDonald's Is Reacting to Their Minimum Wage Concerns*, INDEP. J. REV. (May 26, 2015), http://ijr.com/2015/05/330129-guy-wont-taking-mickey-ds-order-much-longer-might-surprised-reasons/ [https://perma.cc/AZH6-GWXC].

[278] *See* Bertalan Mesko, *Will Robots Take Over Our Jobs in Healthcare?*, *in* MY HEALTH UPGRADED: REVOLUTIONARY TECHNOLOGIES TO BRING A HEALTHIER FUTURE 80, 80–83 (Richard E. Cytowic ed. 2015).

[279] *See Photographer 'Lost £10,000' in Wikipedia Monkey 'Selfie' Row*, BBC (Aug. 7, 2014), http://www.bbc.com/news/uk-england-gloucestershire-28674167 [https://perma.cc/WQF8-KNYL].

[280] *See* Complaint, Naruto v. Slater, 2016 WL 362231 (No. 3:15-cv-04324) at *1, *9 (noting his sale of copies of the Monkey Selfies).

[281] Here that might be the government of Indonesia or the Tangkoko Reserve (Naruto's home) depending on Indonesian law and the reserve's structure. *See* Complaint, *Naruto*, 2016 WL 362231 (No. 3:15-cv-04324) at *1.

[282] *See* Johnson, *supra* note 134, at 16 (describing the sale of works of art created by a chimpanzee whose "fans may have included . . . Pablo Picasso" and works created by seven Asian elephants) (internal quotation marks omitted). Alternatively, in the words of Justice Holmes:

Animal authorship might also have some ancillary conservation benefits. Continuing with the case of the Monkey Selfies, Naruto is a member of a critically endangered species with a total population of between four and six thousand macaques.[283] The species' "numbers have decreased by approximately ninety percent (90%) over the last twenty-five years due to human population encroachment, being killed by humans in retribution for foraging on crops, and being trapped and slaughtered for bush meat."[284] Permitting Naruto's activities to have a new source of value would be another economic incentive for private and public landowners to conserve biodiversity.[285] Naruto lives in a reserve in Indonesia, but the United States also continues to suffer significant biodiversity loss.[286] Some environmentalist groups argue this is because conservation efforts are chronically underfunded.[287] Nonhuman authorship might be an additional policy lever to reverse this trend.

D. Rethinking the Ultimate Test of Patentability

Considering the case for creative computers provides insight into other areas of patent law. Take, for instance, the nonobviousness requirement for grant of a patent.[288] When Congress did away with the Flash of Genius doctrine, it replaced that test with the current requirement for nonobviousness.[289] Part of the requirement's evaluation involves employing the legal fiction of a "person having ordinary skill in the art" ("PHOSITA" or simply the "skilled person") who serves as a reference for determining whether an invention is nonobvious.[290] Essentially, an applicant cannot obtain a patent if the skilled person would have found the difference between a new invention and the prior

---

> It would be a dangerous undertaking for persons trained only to the law to constitute themselves final judges of the worth of pictorial illustrations, outside the narrowest and most obvious limits. At the one extreme some works of genius would be sure to miss appreciation. . . . At the other end, copyright would be denied to pictures which appealed to a public less educated than the judge.

Bleistein v. Donaldson Lithographing Co., 188 U.S. 239, 251–52 (1903).

[283] *See* Complaint, *Naruto*, 2016 WL 362231 (No. 3:15-cv-04324), at *3.

[284] *Id*.

[285] For a discussion of existing economic incentives for landowners to conserve biodiversity, see generally Frank Casey et al., *Incentives for Biodiversity Conservation: An Ecological Is Economic Assessment*, DEFENDERS OF WILDLIFE (2006), http://www.defenders.org/publications/incentives_for_biodiversity_conservation.pdf [https://perma.cc/LEM8-SPYC].

[286] *See id*. at 7.

[287] *Id*. at 8.

[288] *See* 35 U.S.C. § 103 (2012).

[289] *See id.*

[290] Actually, the skilled person is relevant to many areas of patent law including claim construction, best mode, definiteness, enablement, and the doctrine of equivalents. *See* Dan L. Burk & Mark A. Lemley, *Is Patent Law Technology-Specific?*, 17 BERKELEY TECH. L.J. 1155, 1186–87 (2002).

art (what came before the invention) obvious.[291] The test presumes that the skilled person is selectively omniscient, having read, understood, and remembered every existing reference from the prior art in the relevant field of invention (analogous art).[292] A federal judge explained that the way to apply the obviousness test is to "first picture the inventor as working in his shop with the prior art references, which he is presumed to know, hanging on the walls around him."[293]

Needless to say, no actual person could have such knowledge, but the standard helps avoid difficult issues of proof related to an inventor's actual knowledge; also, it prevents obvious variations of publically disclosed inventions from being patented.[294] Stopping obvious variations from being patented is important because that prevents the removal of knowledge from the public domain.[295] Inventions which would have been obvious to skilled persons are already within reach of the public.[296] This raises the bar to obtaining a patent—a result that is desirable because patents should not be granted lightly given their anticompetitive effects.[297] At the same time, creating too high a bar to patentability is undesirable because then patents would fail to adequately incentivize researchers. A balance is needed.[298] Ideally, the system would only issue patents for inventions that would not have been created but for the expectation of obtaining a patent.[299] The importance of the nonobvious requirement to patentability has led to its characterization as the "ultimate condition of pa-

---

[291] *See* 35 U.S.C. § 103(a).

[292] *See* Standard Oil Co. v. Am. Cyanamid Co., 774 F.2d 448, 454 (Fed. Cir. 1985). *See generally* Lance Leonard Barry, *Cézanne and Renoir: Analogous Art in Patent Law*, 13 TEX. INTELL. PROP. L.J. 243 (2005) (discussing analogous art).

[293] *Application of* Winslow, 365 F.2d 1017, 1020 (C.C.P.A. 1966).

[294] *See* Jonathan J. Darrow, *The Neglected Dimension of Patent Law's PHOSITA Standard*, 23 HARV. J.L. & TECH. 227, 228 (2009); Daralyn J. Durie & Mark A. Lemley, *A Realistic Approach to the Obviousness of Inventions*, 50 WM. & MARY L. REV. 989, 991–92, 1017 (2008).

[295] *See* Sakraida v. Ag Pro, Inc., 425 U.S. 273, 281 (1976) ("A patent . . . which only unites old elements with no change in their respective functions . . . obviously withdraws what already is known into the field of its monopoly and diminishes the resources available to skillful men . . . .") (internal quotation marks omitted) (quoting Great Atl. & Pac. Tea Co. v. Supermarket Equip. Corp., 340 U.S. 147, 152–53 (1950))

[296] *See id.*

[297] *See* Eldred v. Ashcroft, 537 U.S. 186, 246 (2003) (Breyer, J., dissenting) (discussing the views of Madison, Jefferson "and others in the founding generation, [who] warned against the dangers of monopolies").

[298] *See* Edmund W. Kitch, Graham v. John Deere Co.*: New Standards for Patents*, 1966 SUP. CT. REV. 293, 301 ("The non-obviousness test makes an effort, necessarily an awkward one, to sort out those innovations that would not be developed absent a patent system.").

[299] Graham v. John Deere Co., 383 U.S. 1, 11 (1965) ("The inherent problem was to develop some means of weeding out those inventions which would not be disclosed or devised but for the inducement of a patent.").

tentability."[300] The idea of a PHOSITA understanding all of the prior art in her field was always fictional,[301] but now it is possible for a skilled entity, in the form of a computer, to possess such knowledge. For example, Watson's database could be populated with every published food recipe available to the Patent Office. This makes the skilled computer a natural substitute for the hypothetical skilled person. The standard would require a skilled computer rather than a creative computer for the same reason that the skilled person is not an inventive person.[302] PHOSITA has traditionally been characterized as skilled at repetitive processes that produce expected results.[303] If the skilled person were capable of inventive activity, then inventive patent applications would appear obvious.[304]

Replacing the skilled person with the skilled computer suggests a change to the nonobviousness test. At present, the test takes into account the skilled person's knowledge of the prior art. Decreasing the universe of prior art makes it easier to get a patent because, with less background knowledge, a new invention is more likely to appear inventive.[305] Likewise, expanding the universe of prior art would raise the patentability bar.[306] Yet although it may be unrealistic

---

[300] *See* NONOBVIOUSNESS—THE ULTIMATE CONDITION OF PATENTABILITY 23 (John Witherspoon ed., 1980) (commemorating the twenty-fifth anniversary of the passage of 35 U.S.C. § 103 (2012)).

[301] *See* Dan L. Burk, *The Role of Patent Law in Knowledge Codification*, 23 BERKELEY TECH. L.J. 1009, 1025 (2008) ("[T]he PHOSITA is a fictional composite, a conceptual construct imagined for the purpose of assessing the claimed invention against its technological antecedents."); Cyril A. Soans, *Some Absurd Presumptions in Patent Cases*, 10 PAT. TRADEMARK & COPY. J. RES. & ED. 433, 438–39 (1967) (railing against the judicially created "superhuman Frankenstein monster Mr. Phosita").

[302] Factors to consider in determining the level of ordinary skill in the art include: (1) "type of problems encountered in the art"; (2) "prior art solutions to those problems"; (3) "rapidity with which innovations are made"; (4) "sophistication of the technology"; and (5) "educational level of active workers in the field." *In re* GPAC Inc., 57 F.3d 1573, 1579 (Fed. Cir. 1995). The U.S. Court of Appeals for the Federal Circuit has acknowledges that "[i]n a given case, every factor may not be present, and one or more factors may predominate." *See id*.; *see also* Custom Accessories, Inc. v. Jeffrey-Allan Indus., Inc., 807 F.2d 955, 962–63 (Fed. Cir. 1986) (discussing PHOSITA); Envtl. Designs, Ltd. v. Union Oil Co. of Cal., 713 F.2d 693, 696–97 (Fed. Cir. 1983) (providing precedent upon which Federal Circuit Court of Appeals in *GPAC, Inc.* relied).

[303] Hotchkiss v. Greenwood, 52 U.S. (11 How.) 248, 253 (1850) (noting patentability requires more "ingenuity or skill" than would be possessed by "an ordinary mechanic acquainted with the business"). The Court noted in 2007 in *KSR International Co. v. Teleflex Inc.* that "[a] person of ordinary skill is also a person of ordinary creativity, not an automaton." 550 U.S. 398, 421, 424 (2007) (referring to PHOSITA as a "pedal designer of ordinary skill" in a case involving pedal design).

[304] *See KSR International Co.*, 550 U.S. at 424.

[305] *See In re* Clay, 966 F.2d 656, 658 (Fed. Cir. 1992) (noting that "the scope and content of the prior art" is relevant to a determination of obviousness).

[306] *See id.*; *see also* Brenda M. Simon, *The Implications of Technological Advancement for Obviousness*, 19 MICH. TELECOMM. & TECH. L. REV. 331, 333, 350–51 (2013) (arguing that "the availability of information in a searchable form and the use of increased processing capabilities" will result in "very few" inventions being held nonobvious and that at some point AI "might become sufficiently

to expect a human inventor to have knowledge of prior art in unrelated fields, there is no reason to limit a computer's database to a particular subject matter. A human inventor may not think to combine cooking recipes with advances in medical science, but a computer would not be limited by such self-imposed restrictions. Now that humans and computers are competing creatively, the universe of prior art should be expanded.

This change would produce a positive result.[307] The PHOSITA standard has been the subject of extensive criticism, most of which has argued the criteria for assessing nonobviousness are not stringent enough and therefore too many patents of questionable inventiveness are issued.[308] Expanding the scope of prior art would make it more challenging to obtain patents, particularly combination patents.[309] The Supreme Court has particularly emphasized "the need for caution in granting a patent based on the combination of elements found in the prior art."[310] The scope of analogous prior art has consistently expanded in patent law jurisprudence, and the substitution of a skilled computer would complete that expansion.[311]

Of course, the new standard would pose new challenges. With human PHOSITAs, juries are asked to put themselves in the shoes of the skilled person and decide subjectively what that person would have considered obvious. A jury would have a difficult time deciding what a "skilled" computer would consider obvious. They could consider some of the same factors that are applied to the skilled person,[312] or perhaps the test could require a combination of

---

sophisticated to ascertain what references those in the art would have actually considered at the time of invention, making the obviousness determination more predictable").

[307] *See generally* Robert P. Merges, *Uncertainty and the Standard of Patentability*, 7 HIGH TECH. L.J. 1, 14–15 (1992) (advocating for an objective PHOSITA standard). For an alternative perspective, see, for example, Durie & Lemley, *supra* note 294, at 991–92, 1017, arguing that "*KSR* overshoots the mark" in raising the patentability bar and advocating for a skilled person standard based "on what the PHOSITA and the marketplace actually know and believe."

[308] Critics have argued that the USPTO has issued too many invalid patents that unnecessarily drain consumer welfare, stunt productive research, and unreasonably extract rents from innovators. *See generally* Michael D. Frakes & Melissa F. Wasserman, *Does the U.S. Patent and Trademark Office Grant Too Many Bad Patents?: Evidence from a Quasi-Experiment*, 67 STAN. L. REV. 613 (2015) (describing the "general consensus that the [US]PTO allows too many invalid patents to issue").

[309] *See KSR Int'l Co.*, U.S. 550 at 420 (noting that "in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle").

[310] *See id.* at 415.

[311] *See, e.g.*, George. J. Meyer Mfg. Co. v. San Marino Elec. Corp., 422 F.2d 1285, 1288 (9th Cir. 1970) (discussing the expansion of analogous art); Innovative Scuba Concepts, Inc., v. Feder Indus., Inc., 819 F. Supp. 1487, 1503 (D. Colo. 1993) (discussing the expansion of analogous art).

[312] Factors to consider in determining the level of ordinary skill in the art include: (1) "type of problems encountered in the art"; (2) "prior art solutions to those problems"; (3) "rapidity with which innovations are made"; (4) "sophistication of the technology"; and (5) "educational level of active workers in the field." *GPAC, Inc.*, 57 F.3d at 1579. "In a given case, every factor may not be present, and one or more factors may predominate." *Id.*

human and computer activity. For example, the skilled computer might be a skilled person with access to a computer's unlimited database of prior art.

CONCLUSION

It is important for policy makers to give serious consideration to the issue of computer inventorship. There is a need for the Patent Office to issue guidance in this area, for Congress to reconsider the boundaries of patentability, and for the courts to decide whether computational invention is worthy of protection. Doing so and recognizing that computers can be inventors will do more than address an academic concern; it will provide certainty to businesses, fairness to research, and promote the progress of science. In the words of Thomas Jefferson, "ingenuity should receive a liberal encouragement."[313] What could be more ingenious than creative computers?

[313] Diamond v. Chakrabarty, 447 U. S. 303, 308 (1980) (quoting 5 WRITINGS OF THOMAS JEFFERSON 75–76 (H. Washington ed. 1871)). "In choosing such expansive terms [for the language of Section 101] . . . modified by the comprehensive 'any,' Congress plainly contemplated that the patent laws would be given wide scope . . . . *Id.*