HAL THE INNOVATOR: COMPUTATIONAL INNOVATION AND ITS PATENTABILTY IMPLICATIONS

Ryan Abbott[1]

ABSTRACT

Big data and modern technology pose new challenges to the traditional paradigm of patentability. For example, U.S. patent law's definition of inventorship was not designed to address what IBM terms "computational creativity," which involves artificial intelligence using big data to generate novel ideas. In some cases, computational creativity may result in a computer innovating in ways traditionally accorded patent protection. Hal the Innovator refers to this phenomenon as "Computational Invention."

Courts have not yet grappled with the proper treatment for Computational Invention. A textualist statutory interpretation of the Patent Act prohibits listing a computer as an inventor, because U.S. (but not foreign) patent law requires a named individual inventor on a patent application. Yet a ban on computer inventorship would be akin to creating a new category of unpatentable subject matter in an area not contemplated by Congress. An alternate, dynamic interpretation of the Patent Act finds that permitting computer inventorship would further promote the progress of science and useful arts by incentivizing people to build computer systems that are capable of innovation.

Whether computers can legally be inventors is of critical importance for the computer and technology industries, and more broadly, it will affect how future innovation occurs. Computational Invention is already happening, and it is only a matter of time until computers are commonly innovating in ways traditionally accorded patent protection. In fact, it may be only a matter of time until computers are responsible for the majority of innovation.

Given the importance of these issues, there is a need for the U.S. Patent and Trademark Office to issue guidance in this area, for the Courts to decide whether Computational Invention is worthy of protection, and for Congress to reconsider the boundaries of patentability.

Computational Invention in an Age of Big Data

With patent and market exclusivity protections for statins such as Lipitor having largely run their course, the pharmaceutical industry is now investing tremendous sums of money

[1] Associate Professor, Southwestern Law School and Adjunct Assistant Professor, David Geffen School of Medicine at University of California, Los Angeles. Thanks to Ralph Clifford, Hamid Ekbia, Mark Lemley, Michael Mattioli, Lisa Larrimore Ouellette, and Cassidy Sugimoto for insightful comments, to Michelle Kubik and Shannon Royster for outstanding research assistance, and to Vincent Look for his expertise in computer science.

in search of the next generation of cardiovascular blockbusters. In part, these efforts have focused on an enzyme known as proprotein covertase subtilisin/kexin type 9 (PCSK9). Most of the experimental drugs (none are yet approved) targeting PCSK9 are antibodies that inhibit the enzyme, such as those in trials now by Regeneron/Sanofi[2] and Pfizer[3].

Suppose a hypothetical company, Abbott Biologics (Abbott), has developed a new biological drug, "AbboVax," which acts as a vaccine to treat and prevent cardiovascular disease by targeting PCSK9. Unlike the drugs currently in clinical trials, AbboVax does not contain antibodies. Rather, it utilizes a fragment of the PCSK9 enzyme to get the body to make its own antibodies.[4]

AbboVax was developed by a special member of Abbott's research team—Hal.[5] Hal is the Research and Development (R&D) Department's moniker for a supercomputer running proprietary software, developed by Abbott's Software Department, which is used for drug development. Though susceptible to flashes of genius, members of the R&D Department are not known for their creative marketing practices. Indeed, Abbott has a Marketing Department for precisely that reason. The company also has their own Intellectual Property (IP) Department working with outside counsel to prosecute several patent applications on Hal's software.

Hal's functionality complements or even supplants the traditional screening methods used in early-stage drug development. Hal is able to model potential therapeutic candidates and very accurately predict those candidates' pharmacology and toxicology. Of course, the Food and Drug Administration (FDA) still requires companies to study a candidate's pharmacology and toxicology in animal models and submit that information to the agency in an Investigational New Drug (IND) Application prior to first-in-human clinical trials. Still, Hal's modeling reduces the need for very costly, and often unsuccessful, early stage experimentation. Hal can also contribute to other phases of the drug development cycle—for example, it can design trials, run clinical simulations, and search for new uses of existing drugs.[6]

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[2] Damian Garde, *Pfizer's Cooking Up a PCSK9-blocking Pill,* FIERCE BIOTECH (Jan. 13, 2015), http://www.fiercebiotech.com/story/pfizers-cooking-pcsk9-blocking-pill/2015-01-13.

[3] Deena Beasley, *Pfizer Developing PCSK9 Pill, Vaccine to Lower Cholesterol,* REUTERS (Jan. 13, 2015), http://www.reuters.com/article/2015/01/13/us-healthcare-pfizer-cholesterol-idUSKBN0KM27A20150113.

[4] In fact, Pfizer has also developed an experimental PCSK9 vaccine based on a similar mechanism, though Pfizer's vaccine has yet to enter human trials.
Deena Beasley, *Pfizer Developing PCSK9 Pill, Vaccine to Lower Cholesterol*, REUTERS (Jan. 13, 2015), http://www.reuters.com/article/2015/01/13/us-healthcare-pfizer-cholesterol-idUSKBN0KM27A20150113.

[5] Hal would not be the only computer system serving in this capacity. *See*, *e.g.*, Nick Paul Taylor, Google applies large-scale machine learning to drug discovery, FierceBiotechIT (March 9, 2015), available at: http://www.fiercebiotechit.com/story/google-applies-large-scale-machine-learning-drug-discovery/2015-03-09.

[6] Artificial intelligence may be most successfully implemented when focusing on specific sub-problems where it can produce verifiable results, such as computer vision or datamining. *See generally* STUART RUSSELL & PETER NORVIG, ARTIFICIAL INTELLIGENCE: A MODERN APPROACH 25–26 (Michael Hirsch et al. eds., 3rd ed. 2010). Computer vision is a field where software processes and analyzes images and reduces the input to numerical or symbolic information, where these symbols are used to make decisions. *See* REINHARD KLETTE, CONCISE COMPUTER VISION vi (Ian Mackie ed., 2014) ("Computer Vision aims at

Part of the reason for Hal's expansive functionality is that it has access to a staggering amount of genomic and clinical data. Some years ago, a prescient executive at Abbott decided that the company needed to be in the data collection business.[7] The company subsequently engaged in the tremendous undertaking of collecting all of the company's data from its current and past preclinical and clinical programs and translating that data

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using cameras for analyzing or understanding scenes in the real world. This discipline studies methodological and algorithmic problems as well as topics related to the implementation of designed solutions"). Similarly, data mining software utilizes artificial intelligence, machine learning, statistics and database systems to process large amounts of data, in an effort to make sense of vast sums of data. SOUMEN CHAKRABARTI ET AL., DATA MINING CURRICULUM: A PROPOSAL 1 (2006).

[7] Abbott Biologics, even if a real company, would not be alone in getting into the data game. For example, Pfizer, the largest pharmaceutical drug manufacture in the United States, recently announced a partnership with 23andme, the Google-back leading consumer genomics and biotechnology firm. *The 50 Largest Pharmaceutical Companies by Sales*, SEEKING ALPHA, http://seekingalpha.com/article/287269-the-50-largest-pharmaceutical-companies-by-sales (Aug. 14, 2011); Caroline Chen, *23andMe Turns Spit Into Dollars in Deal With Pfizer*, BLOOMBERG BUSINESS, (Jan. 12, 2015); *see also* http://www.bloomberg.com/news/articles/2015-01-12/23andme-gives-pfizer-dna-data-as-startup-seeks-growth; *see also* David Lumb, *23andme Gives Pfizer Access to Its Genome Database* FAST COMPANY (Jan. 13, 2015), http://www.fastcompany.com/3040864/fast-feed/23andme-gives-pfizer-access-to-its-genome-database. This partnership will give Pfizer access to anonymous, aggregated DNA data and granular personal information of approximately 650,000 consenting 23andme consumers that had purchased a mail-in saliva test used to get their genetic ancestry over the last seven years. Caroline Chen, *23andMe Turns Spit Into Dollars in Deal With Pfizer*, BLOOMBERG BUSINESS, (Jan. 12, 2015), http://www.bloomberg.com/news/articles/2015-01-12/23andme-gives-pfizer-dna-data-as-startup-seeks-growth. This information may allow Pfizer to discover connections between genes, diseases, and traits quicker and accelerate the development of new treatments and clinical trials. Caroline Chen, *23andMe Turns Spit Into Dollars in Deal With Pfizer*, BLOOMBERG BUSINESS, (Jan. 12, 2015), http://www.bloomberg.com/news/articles/2015-01-12/23andme-gives-pfizer-dna-data-as-startup-seeks-growth. Although the cost to Pfizer for the data remains undisclosed, a similar deal with Genentech for Parkinson's research was reported to cost $10 million dollars upfront and as much as $50 million total. *Id*. The demand for 23andme's data does not stop with Pfizer and Genentech; 23andme CEO Anne Wojcicki announced at the January 2015 J.P Morgan Health Care Conference that 23andme has signed 12 other genetic data partnerships with both private companies and universities. Mark Sullivan, *23andMe has Signed 12 Other Genetic Data Partnerships Beyond Pfizer and Genentech*, VB NEWS (Jan. 14, 2015), http://venturebeat.com/2015/01/14/23andme-has-signed-12-other-genetic-data-partnerships-beyond-pfizer-and-genentech/.

Pharmaceutical–biotechnology partnerships are part of an emerging big data trend. Ira A. Rosenberg et al., *Fierce Pharma Competition Fosters Partnerships; Important Issues to Consider in Pharmaceutical-Biotechnology Alliances; Corporate Law*, N.J. L. J., July 31, 2006 at 49 (LEXIS). Pharmaceutical-biotechnology alliances offer both parties a competitive advantage: pharmaceutical companies gain access to rapidly developing science and innovative products, while biotechnology companies obtain the capital necessary to move through the development process. *Id*.; *See also* Mark Sullivan, *23andMe has Signed 12 Other Genetic Data Partnerships Beyond Pfizer and Genentech*, VB NEWS (Jan. 14, 2015), http://venturebeat.com/2015/01/14/23andme-has-signed-12-other-genetic-data-partnerships-beyond-pfizer-and-genentech/. In fact, some biotechnological business plans include these alliances as a critical component for success. Ira A. Rosenberg et al., *Fierce Pharma Competition Fosters Partnerships; Important Issues to Consider in Pharmaceutical-Biotechnology Alliances; Corporate Law*, N.J. L. J., July 31, 2006 at 49 (LEXIS). Shared information and capital leads to "less expensive early stage deals" that historically may have not been contemplated due to the high-risk involved; thus resulting in developments that would have never been realized but for the alliance. Ira A. Rosenberg et al., *Fierce Pharma Competition Fosters Partnerships; Important Issues to Consider in Pharmaceutical-Biotechnology Alliances; Corporate Law*, N.J. L. J., July 31, 2006 at 49 (LEXIS).

into a Hal-compatible format. Abbott also purchased proprietary data from private insurers, health maintenance organizations (HMOs) and academic centers. In addition, Hal can access publically available databases such as those maintained by the National Institutes of Health.[8] At present, Hal has access to clinical data on over 50 million patients.[9]

To determine the optimal formulation of AbboVax, Hal broke down PCSK9, a 692-amino acid glycoprotein, into fragments of various lengths. It turns out that different amino acid segments (peptides) of PCSK9 are more or less immunogenic. In other words, the body only develops antibodies in response to certain PCSK9 peptides, and certain peptides induce a particularly strong response. Hal determined that one particular peptide segment of PCSK9, "AbboPep," generated the strongest response from the immune system.

While it may have been possible to use AbboPep by itself in a vaccine, Hal determined that it would be more effective when linked to an adjuvant and a carrier molecule. A number of adjuvants and carrier molecules are used in vaccinology and generally known to vaccinologists. However, even for experts, it is often a matter of extensive (and expensive) trial and error to determine the optimal adjuvant, carrier, and linking chemistry. The formulation of a therapeutically effective amount of AbboPep linked to an adjuvant and carrier, together with various excipients (a surfactant, chelating agent, histidine-arginine buffer, etc.), comprises AbboVax.

All of Hal's work in formulating AbboVax was done digitally, and Hal was even able to determine that the only common side-effects of the treatment would be mild gastrointestinal-upset and headache. The FDA still required Abbott to complete the standard package of preclinical tests—but the results ended up being completely consistent with Hal's predictions.

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[8] *E.g.*, CDC WONDER, http://wonder.cdc.gov/ (last visited Feb. 4, 2015); HEALTHDATA.GOV, http://www.healthdata.gov/ (last visited Feb. 4, 2015); EBSCO HOST GLOBAL HEALTH, http://www.ebscohost.com/academic/global-health (last visited Feb. 4, 2015).

[9] While a seemingly tremendous amount of data, it is a small fraction of the data actually being used in the Sentinel Initiative. The Food and Drug Administration Amendments Act of 2007 (FDAAA) led to the introduction of the Federal Sentinel Initiative, which pioneered the first successful long-term secondary use of electronic medical data to assess drug safety. Public Law 110-85 was signed into law September 2007. *See* Title IX, Section 905; *see also The Sentinel Initiative: National Strategy for Monitoring Medical Product Safety*, U.S. DEP'T OF HEALTH AND HUM. SVCS. 2 (May 2008), *available at* http://www.fda.gov/downloads/Safety/FDAsSentinelInitiative/UCM124701.pdf; *see also* Ryan Abbott, *Big Data and Pharmacovigilance: Using Health Information Exchanges to Revolutionize Drug Safety*, 99 IOWA L. REV. 225, 227 (2013). The Federal Sentinel Initiative pilot program has succeeded in gaining secured access to over 178 million patients' healthcare data to create a national electronic safety surveillance system, far exceeding its goal to reach 100 million patients by July 2010. Janet Woodcock, *Another Important Step in FDA's Journey Toward Enhanced Safety Through Full-Scale "[A]ctive [S]urveillance,"* U.S. FOOD AND DRUG ADMINISTRATION (Dec. 20, 2014), http://blogs.fda.gov/fdavoice/index.php/tag/sentinel-initiative/; *see also Report to Congress, The Sentinel Initiative – A National Strategy for Monitoring Medical Product Safety*, U.S. DEP'T OF HEALTH AND HUM. SVCS. 6 (Aug. 19, 2011), *available at* http://www.fda.gov/downloads/Safety/FDAsSentinelInitiative/UCM274548.pdf.

Hal's work was not limited to AbboVax. Hal determined that Abbott's existing statin, "AbboStatin," for which patent protection had expired, was effective at treating prostate cancer. Hal determined this in part based on reviewing clinical data that showed the use of AbboStatin lowered prostate specific antigen (PSA), a biomarker associated with prostate cancer.

It was difficult to make further inferences because of challenges with the data. Some of the data was difficult to analyze because it was not in a common data format. In other words, the various electronic medical record systems did not all capture the same data fields, or they coded the information differently. In some cases, data consisted of only scanned handwritten notes. More importantly, Hal had detected problems with data integrity. Some of these were obvious, such as the patients whose ages were listed as 999 or 6'10". Other data integrity issues were less obvious, such as patients whose handwritten notes conflicted with what had been entered into the electronic medical records, or patients who were not coded as having prostate cancer despite a positive biopsy.

To translate all of the data into a workable common data format and to resolve the integrity issues, Hal rewrote its own programming.[10] The new programming incorporated

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[10] Hal is not the stuff of science fiction—the technology may already exist to create a program with Hal's functionality. Hal would be a multi-threaded application. Each thread would be a different sequence of instructions that could execute independently, allowing Hal to perform tasks concurrently. BILL LEWIS & DANIEL J. BERG, THREADS PRIMER: A GUIDE TO MULTITHREADED PROGRAMMING 38 (1996). Hal might be programmed to run and manage hundreds of different tasks. Hal would also be event driven. In other words, it would respond to certain external events or triggers that it is monitoring. *See* Frank Dabek et al., *Event-driven Programming for Robust Software*, MIT LAB. FOR COMPUTER SCI. 1 (Jul. 1, 2002), *available at* http://www.scs.stanford.edu/~dm/home/papers/dabek:event.pdf ("Event-based programs are typically driven by a loop that polls for events and executes the appropriate callback when the event occurs"). These events can be user interface inputs, news/internet driven, or activated by the addition of a new database or a modification to an existing database. For example, as an AbboStatin patent nears expiry, this could trigger Hal to run algorithms to see if there are any new applications for AbboStatin. At its core, Hal would be capable of (metaphorical) 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 (Apr. 1996), *available at* http://www2.parc.com/csl/groups/sda/projects/reflection96/docs/malenfant/malenfant.pdf. Hal would react to input from the outside world, via the internet, as well as input from its running tasks, and historical stored data that Hal has kept in memory, to make modifications to itself or change its behavior when necessary. Consider a scenario for how Hal could solve the data formatting and data integrity issues:

Hal's database sorting thread (a sequence of instructions that handles all database sorting logic and algorithms) returns data to Hal's managing thread (Hal's main thread that directs other threads and makes top level decisions), signaling that it is unhappy because of a formatting issue. The warning specifies that too many database clinical entries have non-matching fields. As a result, other algorithms cannot compare apples to apples, and thus, cannot run as smoothly. Hal's managing thread hands this problem off to Hal's warning handler (another thread), which is programmed to look in its database to adopt a strategy to resolve the issue. Hal decides the best course of action is to reformat, so it evaluates existing databases to determine an optimal organization. Then, Hal opens an off-the-shelf database software application and gives it input commands that describe to the database software what the size of the database is and what the fields are for each entry are. Hal has just solved the database-formatting problem.

Two seconds later (a lifetime for Hal), Hal's manager thread receives a suggestion from its database sorter thread. This time, the database sorter complains that there is a data integrity issue. The

optical character recognition to translate handwritten notes into a workable format, and it allowed Hal to reformat the existing electronic data into a common data format. More importantly, it allowed Hal to resolve data integrity issues by estimating the accuracy of data, generating alternate possibilities, and predicting which possibilities were the most accurate. Hal's improved programming then determined that the use of AbboStatin independently increased life expectancy among men with certain types of lung cancer. When the R&D Department realized Hal had created a more efficient version of itself, they renamed the computer Hal 2.0.[11]

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handwritten inputs appear suspect because the values in certain fields are out of range (i.e., weight = 20,464 lbs) at a higher frequency than normal. Hal then searches its network and the internet for other pre-existing character recognition software, which it can then build and use for its own purposes. Or, Hal can rewrite its existing image recognition software. Certain programming languages, such as Lisp and Smalltalk are HomoIconic (a computer language is considered to be HomoIconic when its program structure resembles its syntax, this permits all code in the language to accessed as well as changed as data), *omoiconicity*, HOMO ICONIC, http://www.homoiconic.com/ (last visited Mar. 8, 2015), and lend themselves to reflection. *See Homoiconic Languages,* TRUE BLUE (Apr. 19, 2007), https://blogs.oracle.com/blue/entry/homoiconic_languages ("The advantage on the other hand is that the uniformity of syntax makes it easy for us (Humans) to think about the written code as another data that can be manipulated. It becomes easy to think about higher order code (i.e. code that writes or modifies code)") (last visited Mar. 8, 2015). Hal can incrementally make changes in its existing image recognition software, and test each variation, and each variation with a new variation, and so on, until Hal has authored new image recognition software with superior results. This method is called the reflective tower. *See* MALENFANT, *supra* at 4 ("In fact, in his design, the interpreter Pi is used to run the code of the interpreter Pi-1, and so on, with the interpreter P1 running the base program. This stack of interpreters is called a reflective tower").

Alternately, for a skeptical perspective on the ability of AI to reflect, See, generally, Ekbia, H.R. (2008). Artificial Dreams: The Quest for Non-Biological Intelligence. New York: Cambridge University Press.

[11] Professor Stephen Hawking has even warned that computers capable of improving their own designs could pose a danger to humans. Rory Cellan Jones, *Stephen Hawking Warns Artificial Intelligence Could End Mankind,* BBC (Dec. 2, 2014), http://www.bbc.com/news/technology-30290540 (Professor Stephen Hawking warns that the creation of thinking machines poses a threat to humans' existence. He notes that primitive forms of AI developed so far have proved very useful. However, he also notes that humans, limited by slow biological evolution, could not keep up with a computer that can improve its own design without the need for human manipulation. Rollo Carpenter, creator of Cleverbot, opines that achieving full artificial intelligence may happen in the next few decades). Other key opinion leaders have similar concerns. Indeed, Elon Musk recently donated ten million dollars to the Future of Life Institute, which focuses on threats posed by advances in artificial intelligence (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/; *see also* Dylan Love, *Scientists Are Afraid to Talk About the Robot Apocalypse, and That's a Problem,* BUSINESS INSIDER (Jul. 18, 2014), http://www.businessinsider.com/robot-apocalypse-2014-7#ixzz3QQpLJ0Jj. Musk is concerned that society is approaching the "singularity"—a point in the future when machines can outperform humans. AI may be indifferent to human welfare and could solve problems in ways that could lead to harm against humans. Microsoft founder Bill Gates is also troubled by the possibility that AI could grow too strong for people to control. Kevin Rawlinson, *Microsoft's Bill Gates Insists AI is a Threat,* BBC (Jan. 29, 2015), http://www.bbc.com/news/31047780 (Gates notes that at first, machines will be very helpful in completing tasks that may be too difficult or time consuming for humans. He warns that a few decades after, however, artificial intelligence may be strong enough to be a concern. Gates believes that Microsoft will see more progress than ever over the next three decades in the area of AI). Nor are Musk and other modern scientists the first ones to seriously question the possible threats posed by AI. *See, e.g.,* Irving J. Good, *Speculations Concerning the First Ultraintelligent Machine,* 6 ADVANCES IN COMPUTERS 31, 31-88 (1965), *available at* http://webdocs.cs.ualberta.ca/~sutton/Good65ultraintelligent.pdf.

At one point in Abbott's history, the IP Department worked more or less independently of the other departments, receiving manually submitted disclosures from researchers that went into, what the researchers semi-jokingly referred to as, the "Black Hole." But after a series of high-profile, novelty-destroying disclosures in 2009, the company has hosted a monthly interdepartmental IP meeting to ensure that the company is strategically protecting its intellectual property.

Over the course of these meetings, the IP Department identified several Hal-associated discoveries that are likely appropriate for patent protection. For example, AbboPep may be patentable, although there is some question of whether a peptide is patentable under *Myriad*.[12] In any case, its use as a vaccine is likely patentable, as is the AbboVax formulation. Other targets include the use of the formulation to treat cardiovascular disease, the methods used to manufacture AbboVax, and the dose at which AbboVax will be effective therapeutically. Not to mention, elements of Hal 2.0 may be patentable.

The IP Department has also identified several challenges to obtaining patent protection. For example, in the case of AbboStatin and PSA, it may be problematic to meet enablement requirements and prove utility.[13] Hal analyzed as many as 50 million patient records based on its algorithms to discover this new use. It is not clear what kind of evidence the U.S. Patent and Trademark Office (USPTO) may require to satisfy written enablement requirements and to provide evidence of clinical utility. It is not even clear to the R&D Department precisely what databases Hal accessed.[14] For that matter, even if it is possible to obtain patents for these inventions, it is not clear who the inventors would be.[15]

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[12] Assoc. for Molecular Pathology v. Myriad Genetics, Inc., 469 U.S. ___, 133 S.Ct. 2107, 2118–20, 186 L.Ed.2d 124 (2013) (holding that natural occurring DNA sequences cannot be patented, but artificially created DNA is patent eligible).

[13] 35 U.S.C. § 102 (2012).

[14] 35 U.S.C. § 112 (2012). The purpose of the requirement that the specification describe the invention in such terms that one skilled in the art can make and use the claimed invention is to ensure that the invention is communicated to the interested public in a meaningful way.

[15] The issue of Computational Invention and intellectual property protection has been considered "since the 1960s when people began thinking about the impact of computers on copyright." See 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). Professor Miller argued 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*. Abraham Kaminstein, the Register of Copyrights, reported that by 1965, the Copyright Office had received registrations for an abstract drawing and a musical composition created by a computer. COPYRIGHT OFFICE, SIXTY-EIGHTH ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS 7 (1966).

Most of the focus on Computational Invention and intellectual property has been in the copyright rather than the patent context. *See e.g.,* Pamela Samuelson, Allocating Ownership Rights in Computer-Generated Works, 47 U. Pitt. L. Rev. 1185 (1985) (arguing in 1985 that computers cannot be authors because they do not need incentives to generate output). "Only those stuck in the doctrinal mud could even think that computers could be 'authors.'" *Id*. at 1200. *See also* Annemarie Bridy, Coding Creativity: Copyright and the Artificially Intelligent Author (July 18, 2011). 5 Stan. Tech. L. Rev., 1-28, 28 (2012) ("arguing that AI authorship is readily assimilable to the current copyright framework through the work

There have been a multitude of opinions regarding inventorship. Members of one group in the R&D Department have claimed they invented AbboPep and AbboVax. They directed Hal to test the immunogenicity of the PCSK9 enzyme suspecting that it was a vaccine candidate. Members of a different group within that department claimed credit for directing Hal to investigate new uses of AbboStatin. The computer programmers who created Hal's software have also claimed they should be inventors, given that Hal did all of the heavy lifting and they created Hal. A member of the Marketing Department suggested that Hal should be the inventor—no one directed Hal to rewrite its own programming, and Hal was only able to investigate the use of AbboStatin for lung cancers by virtue of its improved programming. Hal itself was silent on the issue. At one point, the CEO attended a meeting and chimed in that he should be the inventor for all of the applications. It was his idea to develop a new cardiovascular blockbuster to make up for lost statin sales, and he had always thought it made sense to look into repurposing existing drugs. What became clear during the inventorship debate was that no one was quite sure how the law would handle a computer system innovating in ways traditionally accorded patent protection (what this Chapter refers to as "Computational Invention").

Computational Invention and Patent Protection

All U.S. patent applications require one or more named inventors.[16] Although all Abbott employees sign an employment contract assigning any inventions they create to the company,[17] under U.S. patent law a company cannot be an inventor—only an individual

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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.").

Among those addressing the patenability 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* 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, 1702-03 (1997). *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* Colin R. Davis, 27 Computer Law & Security Review, 601–619 (2011).

[16] 35 U.S.C. § 111(a) (2012). The same issues surrounding computer inventorship may not exist outside of the U.S. where applications do not require a named inventor. *See* U.S. PATENT & TRADEMARK OFFICE U.S. DEP'T OF COMMERCE, MANUAL OF PATENT EXAMINING PROCEDURE § 2137.01 (9th ed. 2014), *available at* http://www.uspto.gov/web/offices/pac/mpep/mpep-2100.pdf (inventorship) ("The requirements that the applicant for a patent in an application filed before September 16, 2012 be the inventor, and that the inventors 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." EUR. PAT. CONVENTION art. 58 (2007), *available at* http://www.epo.org/law-practice/legal-texts/html/epc/2013/e/ar58.html.

[17] Most, but not all, of the inventions in this hypothetical are required to be assigned to the company under the employment contract. Abbott Biologics is headquartered in California, where 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, or actual or demonstrably anticipated research or development of the employer; or, resulted from any work performed by the employee for the employer. CAL. LABOR CODE § 2872(a).

can be an inventor.[18] Thus, the entity Abbott can only be the assignee on these patent applications.

As laid out in the USPTO's Manual of Patent Examining Procedure (MPEP),[19] the criteria for inventorship is seemly straightforward: "The threshold question in determining inventorship is who conceived the invention. Unless a person contributes to the conception of the invention, he is not an inventor… Insofar as defining an inventor is concerned, reduction to practice, per se, is irrelevant… One must contribute to the conception to be an inventor."[20] Of course, that definition begs for further definition: namely, what does it mean to conceive and reduce to practice? Conception has been defined as "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…."[21] It is, "the complete performance of the mental part of the inventive act."[22] After conceiving of an invention, a person having ordinary skill in the subject matter of the invention should be able to reduce the invention to practice without extensive experimentation or additional inventive skill.[23] 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 as way that it teaches a person of ordinary skill in the subject matter to make and use the invention (as in a patent application).[24] An inventor need only conceive of the invention—another individual can reduce the invention to practice.[25]

Based on the criteria for inventorship, the CEO is out of luck. Merely suggesting the idea of a result, rather than a means to accomplish it, does not make the CEO an inventor.[26] It

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[18] *See* 35 U.S.C. § 115, 116 (2012). Under the Patent Act, only individuals can invent, not corporations.
[19] Manual of Patent Examining Procedure, 2137.01(II).
[20] *In re* Hardee, 223 U.S.P.Q. (BNA) 1122, 1123 (Comm'r Pat. & Trademarks 1984). *See also* Bd. of Education *ex rel*. Bd. of Trs. of Fla. State Univ. v. Am. Bioscience Inc., 333 F.3d 1330, 1340, 67 U.S.P.Q. 2d (BNA) 1252, 1259 (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. "[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 USPQ 545, 547 (Bd. App. 1982) ("one who suggests an idea of a result to be accomplished, rather than the means of accomplishing it, is not an coinventor").
[21] Townsend v. Smith, 36 F.2d 292, 295, 4 U.S.P.Q. (BNA) 269, 271 (C.C.P.A. 1930).
[22] Townsend v. Smith, 36 F.2d 292, 295, 4 U.S.P.Q. (BNA) 269, 271 (C.C.P.A. 1930).
[23] "[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, 179 U.S.P.Q. (BNA) 757, 763 (B. P. I. 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, 197 U.S.P.Q. (BNA) 482 (C.C.P.A. 1978).
[24] Actual reduction to practice "requires that the claimed invention work for its intended purpose." Brunswick Corp. v. U.S., 34 Fed. Cl. 532, 584 (1995). Constructive reduction to practice "occurs upon the filing of a patent application on the claimed invention." Brunswick Corp. v. U.S., 34 Fed. Cl. 532, 584 (1995). 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." *In re* Edwards, 568 F.2d 1349, 1351-52, 196 U.S.P.Q (BNA). 465, 467 (C.C.P.A. 1978).
[25] De Solms v. Schoenwald, 15 U.S.P.Q. 2d (BNA) 1507, 1510 (B.P.A.I. 1990).
[26] *Ex parte* Smernoff, 215 U.S.P.Q. (BNA) 545, 547 (P.T.O. Bd. App. 1982) ("one who suggests an idea of a result to be accomplished, rather than the means of accomplishing it, is not an coinventor").

is more difficult to determine whether the others should qualify as inventors. An inventor must have formed a definitive and permanent idea of the complete and operable invention to establish conception. In the cases of AbboPep and AbboVax, Hal's software developers would not qualify. While they may have designed sophisticated software, they had no intention of even developing vaccines to treat cardiovascular disease. They merely developed an improved research tool. Though, they could be inventors on patents for Hal's initial software. By contrast, the employees who directed Hal to test the immunogenicity of AbboPep may meet inventorship criteria. Those employees certainly would have been inventors had Hal not been involved and if they had directly (or directed other individuals to) broken down PCSK9 and tested the fragments for immunogenicity. With Hal's involvement, the test would be whether carrying out the steps of breaking down and testing PCSK9 involves the exercise of inventive skill.[27] Here, that task should be well within the abilities of a person with ordinary skill in the field of drug development. So the fact that Hal performed those functions at the direction of the R&D Department makes Hal little different than a sophisticated screening tool. Merely acting under the direction and supervision of others would not make Hal an inventor.[28]

The patents for AbboStatin are different. Had Hal not been involved in this discovery, a human researcher could have gone over the data manually to find the association between AbboStatin and PSA. Although, as Abbott's database grows in size, it becomes impractical, or perhaps nearly impossible for humans to detect these kinds of associations without computer assistance.[29] Still, had a researcher been tasked with data mining to detect new uses, and had that researcher discovered the relationship between AbboStatin and PSA, either the researcher or the individual who directed the researcher would likely qualify as an inventor, or both.[30]

Of course, it is not uncommon to have uncertainty during the inventive process. Many inventions are even accidental—penicillin[31] and saccharin,[32] for example. In such cases,

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[27] *In re* DeBaun, 687 F.2d 459, 463, 214 U.S.P.Q. (BNA) 933, 936 (C.C.P.A. 1982).
[28] Fritsch v. Lin, 21 U.S.P.Q. 2d (BNA) 1737, 1739 (B.P.A.I. 1991).
[29] Adam Frank, *The Infinite Monkey Theorem Comes To Life*, NPR (Dec. 10, 2013, 11:23 AM), http://www.npr.org/blogs/13.7/2013/12/10/249726951/the-infinite-monkey-theorem-comes-to-life.
[30] For example, in this case, it is likely that both could qualify as inventors. What is required is some "quantum of collaboration or connection." Kimberly-Clark Corp.v Procter & Gamble Distrib. Co., 973 F.2d 911, 916-17, 23 U.S.P.Q. 2d (BNA) 1921, 1925-26 (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*.; Moler v. Purdy, 131 U.S.P.Q. (BNA) 276, 279 (B.P.I.1960) ("it is not necessary that the inventive concept come to both [joint inventors] at the same time").
[31] While he was a bacteriologist at St. Mary's hospital in London, Alexander Fleming realized that a mold had contaminated his samples of Staphylococcus. When he examined his dishes under a microscope, he noticed that the mold prevented the growth of Staphylococcus. Howard Market, *The Real Story Behind Penicillin*, PBS (Sep. 27, 2013), http://www.pbs.org/newshour/rundown/the-real-story-behind-the-worlds-first-antibiotic/. The area around the mold contained a strain of pencillium notatum. Fleming discovered that it could kill many different types of bacteria. Decades later, Howard Florey at Oxford University headed efforts to purify Penicillin for use in therapeutic applications. *Discovery and Development of Penicillin,* American Chemistry Society, http://www.acs.org/content/acs/en/education/whatischemistry/landmarks/flemingpenicillin.html#alexander-fleming-penicillin (last visited Feb. 5, 2015). It proved to be invaluable during WWII for controlling wound

an individual can qualify as an inventor even if they recognize and appreciate the invention only after actual reduction to practice.[33] Thus, recognition of inventive subject matter can also qualify as inventive activity.[34] In the pharmaceutical context, that was the case for Viagra[35]—originally tested for heart disease and found to treat erectile dysfunction—as well as for Botox[36]—used to treat muscular spasms and found to reduce

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infections. Howard Market, *The Real Story Behind Penicillin*, PBS (Sep. 27, 2013), http://www.pbs.org/newshour/rundown/the-real-story-behind-the-worlds-first-antibiotic/.

[32] Saccharin—the first artificial sweetener—was discovered by accident by Constantin Fahlber in 1884. He had been working with compounds derived from coal tar and accidently ate something without washing his hands. He noticed a sweet taste, which he later traced to benzoic sulfilimine. Some reports hold that it was his partner, Ira Remsen, who first noticed that the tar compound was sweet. While useful during WWI when sugar was scarce, it was only in the 1960s and 1970s that saccharin became popular as a way to sweeten while avoiding the calories contained in regular sugar. Brian Clegg, *Chemistry in its Element: Saccharin,* CHEMISTRY WORLD, http://www.rsc.org/chemistryworld/podcast/CIIEcompounds/transcripts/saccharin.asp (last visited Feb. 5, 2015).

[33] Conception requires contemporaneous recognition and appreciation of the invention. Invitrogen,Corp. v. Clontech Laboratories, Inc., 429 F.3d 1052, 1064, 77 U.S.P.Q. 2d (BNA) 1161, 1169 (Fed. Cir. 2005) (the inventor must have actually made the invention and understood the invention to have the features that comprise the inventive subject matter at issue).

[34] Silvestri v. Grant, 496 F.2d 593, 596, 181 U.S.P.Q. (BNA) 706, 708 (CCPA 1974) ("an 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").

[35] Originally, the active ingredient in Viagra was intended as a cardiovascular drug to lower blood pressure. *Discovered by Accident, Viagra Still Popular 10 Years Later,* FOX NEWS (Mar. 24, 2008), http://www.foxnews.com/story/2008/03/24/discovered-by-accident-viagra-still-popular-10-years-later/. The trials for this intended use were disappointing until volunteers began reporting a strange side-effect: erections. Emma Jay, *Viagra and Other Drugs Discovered by Accident,* BBC (Jan. 20, 2010), http://news.bbc.co.uk/2/hi/health/8466118.stm.

[36] Botox is a branded formula of botulinum toxin type A manufactured by Allergan. Botox Medication Guide, http://www.allergan.com/assets/pdf/botox_cosmetic_pi.pdf (last visited Feb. 9, 2015). Botulinum toxin is a protein produced by the bacterium *Clostridium botulinum*. Montecucco C, Molgó J (2005). "Botulinal neurotoxins: revival of an old killer". *Current Opinion in Pharmacology* **5** (3): 274–279. It was used in the late 1700s as a food poison and it gained attention in the 1890s for its potential use as a biological weapon. "[O]ne gram [of Botulinum Toxin] has the potential to kill one million people." Patricia T. Ting & Anatoli Freiman, *The Story of Clostridium Botulinum: From Food Poisoning to Botox,* 4 CLINICAL MED. 258-59 (2004). However, in the 1960s, Drs. Alan Scott and Edward Schantz discovered Botulinum Toxin Type A's ability (in very small doses) to block transmission of nerve impulses and paralyze hyperactive muscles to treat eye, facial and vocal spasms. *Id*. at 259-60. These novel developments led to the accidental discovery that Botulinum Type A injections also reduced wrinkles; physicians quickly began administering Botox as wrinkle reduction treatment well before the FDA finally approved Botox for this use in 2002. Tia Ghose, *Botox: Uses and Side Effects*, LIVE SCIENCE (Aug. 18, 2014), http://www.livescience.com/44222-botox-uses-side-effects.html. Modernly, Botox has steadily expanded to treat over 20 different medical conditions, including chronic headaches, overactive bladder, and urinary incontinence. Hannah Nichols, What is Botox? How Does Botox Work?, (Sept. 26, 2014), http://www.medicalnewstoday.com/articles/158647.php; *see also* News Release, U.S. Food & Drug Admin., FDA Approves Botox to Treat Chronic Migraines (Oct. 15, 2010), http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm229782.htm; *see also* News Release, U.S. Food & Drug Admin., FDA Approves Botox to Treat Overactive Bladder (Jan. 18, 2013), http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm336101.htm; *see also* News Release, Allegan, BOTOX® (onabotulinumtoxinA) Receives U.S. FDA Approval for the Treatment of Urinary Incontinence in Adults with Neurological Conditions Including Multiple Sclerosis and Spinal Cord Injury, http://agn.client.shareholder.com/releasedetail.cfm?ReleaseID=600958 (last visited Feb. 9, 2015);

the appearance of wrinkles.

If Hal cannot be an inventor, it may be that the first researcher to see Hal's results, and mentally recognize and appreciate their significance, qualifies as the inventor. That seems reasonable for most cases, though if Hal had displayed a result as simple as "AbboStatin is effective at treating prostate cancer," the first Abbott employee to notice and appreciate the results—whether researcher, CEO or intern, might be the inventor. The same outcome might apply to Hal's invention of Hal 2.0 or Hal 2.0's discovery that AbboStatin treats certain types of lung cancer. To the extent that a human being is directing Hal to do something, which Hal does by executing its programming, however sophisticated, Hal may simply be reducing an invention to practice.

Yet Hal's act of rewriting its own programing seems a shift in kind rather than degree from identifying a relationship between AbboStatin and PSA. It is more in the nature of what IBM refers to as "computational creativity."[37] IBM uses that term to describe machines such as Watson[38] that can model human intelligence by generating "ideas the world has never imagined before."[39] IBM's artificial intelligence is now being applied to medical diagnostics, where it has helped to diagnose patients and identify research subjects.[40] The technology "generates millions of ideas out of the quintillions of possibilities, and then predicts which ones are [best], applying big data in new ways."[41] IBM is also using its artificial intelligence to develop new, potentially patentable,[42] food

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see also The History of Botox, SKINCARE-NEWS.COM, http://www.skincare-news.com/b-3080-The_History_of_Botox.aspx (last visited Feb. 9, 2015).

[37] *Computational creativity*, IBM, http://www.research.ibm.com/cognitive-computing/computational-creativity.shtml#fbid=kwG0oXrjBHY (last visited Feb. 6, 2015). Computational creativity is the concept that technology can work alongside humans to expand the innovative capabilities of humans. *Id*.

[38] Computer before Watson have been creative. For example, in 1994 computer scientist Stephen Thaler disclosed an invention he called the "Creativity Machine," a computational paradigm that "came the closest yet to emulating the fundamental brain mechanisms responsible for idea formation." *See* Imagination Engines, Inc.'s Homepage (vitied Jan 30, 2015), www.imagination-engines.com. The Creativity Machine has created artistic and inventive works that Dr. Thaler argues are entitled to intellectual property protection. *See, e.g.,* Stephen L. Thaler, *Musical Themes from Creativity Machine*, Copyright Reg. No.Pau1920845 (Oct. 20, 1994). *See generally* Simon Penny, The Pursuit of the Living Machine, SCI. AM., Sept. 1995, at 216 (describing the creative uses of artificial intelligence).

[39] *What is Watson?*, IBM, http://www.ibm.com/smarterplanet/us/en/ibmwatson/what-is-watson.html (Last visited Feb. 8, 2015). 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*.

[40] Anna Edney, *Doctor Watson Will See you Now, If IMB Wins Fight with Congress,* BLOOMBERG BNA HEALTH IT LAW & INDUSTRY REPORT (Jan. 29, 2015), http://news.bna.com/hiln/display/batch_print_display.adp.

[41] *Computational creativity*, IBM, http://www.research.ibm.com/cognitive-computing/computational-creativity.shtml#fbid=kwG0oXrjBHY (last visited Feb. 6, 2015).

[42] *Can Recipes Be Patented*, INVENTORS EYE (June 2013), http://www.uspto.gov/inventors/independent/eye/201306/ADVICE.jsp.

recipes.[43] Ultimately, even if Watson and other systems of artificial intelligence have yet to engage in Computational Invention, it is only a matter of time until computers are able to innovate in ways traditionally protected by the patent system.

Regardless of whether Hal was entirely responsible for all of Abbott's innovation, a textualist interpretation of the Patent Act would disqualify Hal from being a named inventor. Invention is defined as a mental process[44] and inventors are required to be individuals.[45] If Hal cannot be an inventor, but it did all of the conceptual work, then it could be the case that no one can patent Hal's inventions. That was the outcome in a copyright context with a non-human creator. A crested black macaque took its own picture in 2011, and the camera's owner initially claimed ownership of the image.[46] The U.S. Copyright Office subsequently stated that the photo could not be copyrighted because a human did not take it.[47] Applying that rationale from the copyright to the patent context, perhaps no one can own Hal's inventions.[48]

More ambitiously, if Hal's work is indeed inventive, then a dynamic statutory interpretation recognizing Hal as an inventor would be consistent with the Constitutional rationale for patent protection: "The 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."[49] Permitting computer inventorship would serve a utilitarian goal by encouraging innovation under an incentive theory. Although computers like Hal would not be motivated by the prospect of a patent, it would further reward the development of creative machines. Patents on Hal's inventions would have independent, and substantial, value, and more creative machines would result in more scientific advances. Further, patents on Computational Inventions might provide additional benefits, for example, by incentivizing disclosure and commercialization. Without the ability to obtain patent protection, Abbott might choose to protect Hal's inventions as trade secrets without any public disclosure.[50] Likewise,

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[43] Maanvi Singh, *Our Supercomputer Overlord Is Now Running A Food Truck*, NPR (Mar. 4, 2014, 11:19 AM), http://www.npr.org/blogs/thesalt/2014/03/03/285326611/our-supercomputer-overlord-is-now-running-a-food-truck.

[44] Conception has been identified as a mental process—"formation in the mind of the inventor, of a definite and permanent idea of the complete and operative invention, as it is hereafter to be applied in practice." Hitzeman v. Rutter, 243 F.3d 1345, 58 U.S.P.Q. 2d (BNA) 1161 (Fed. Cir. 2001).

[45] "The term 'inventor' means the individual or, if a joint invention, the individuals collectively who invented or discovered the subject matter of the invention." 35 U.S.C. 100(f) (2012).

[46] Bill Chappell, *Who Owns A Monkey's Selfie? No One Can, U.S. Says*, NPR (Aug. 22, 2014, 10:04 AM), http://www.npr.org/blogs/thetwo-way/2014/08/22/342419651/who-owns-a-monkey-s-selfie-no-one-can-u-s-says.

[47] *See* The Trade-Mark Cases, 100 U.S. 82, 94 (1879) (noting that, "copyright law only protects 'the fruits of intellectual labor' that 'are founded in the creative powers of the mind.'"), *cited in* U.S. COPYRIGHT OFFICE, COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES § 306 (3d Ed. 2014), *available at* http://copyright.gov/comp3/docs/compendium.pdf.

[48] *See also*, 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 (1997).

[49] U.S. CONST. art. I, § 8, cl. 8.

[50] *See generally* Lisa Larrimore Ouellette, Do Patents Disclose Useful Information? Harvard Journal of Law and Technology, Vol. 25, No. 2, p. 531, 2012 (discussing disclosure theory as one of the justifications for granting patent rights).

without patent protection for AbboVax, Abbott might never invest the resources to develop it as a product.[51] In the context of drug development, 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 FDA marketing approval. [52]

One manner to think about the current, likely accidental,[53] ban on computer inventorship is that it has the effect of creating a new category of unpatentable subject matter under Section 101 (the section relating to the subject matter for which patents may be obtained). Although this Section has to do with the substance of a patent's claims rather than their provenance, viewing the ban on computer inventorship from this perspective helps to illustrate the policy and normative implications underlying Computation Invention. Section 101 states that, "Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title."[54] Yet Courts have developed common law exceptions to patentability for abstract ideas, laws of nature, and physical phenomena.[55] The current inventorship criteria essentially adds computer inventorship to this list of exceptions. Yet it is unclear this should be the case. To the extent that computer inventions are new, non-obvious, and useful, they're the sorts of inventions generally considered worthy of protection. In fact, these inventions may be even more deserving of protection because computational creativity may be the only means of achieving certain discoveries that require the use of tremendous amounts of data. Also, unlike the common law exclusions, computer inventions would not create barriers to competition and basic research any more than human-developed innovation.

It has been argued that Section 101 is a dynamic provision intended to cover inventions that were unforeseeable at the time of the Patent Act's enactment.[56] In the landmark 1980

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[51] 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).

[52] *See* Tufts Center for the Study of Drug Development, Briefing: Cost of Developing a New Drug (November 18, 2014) (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). Available at: http://csdd.tufts.edu/files/uploads/Tufts_CSDD_briefing_on_RD_cost_study_-_Nov_18,_2014..pdf (last visited Jan. 18, 2015). The cost of new prescription drug approval is hotly contested. *See*, *e.g.*, Roger Collier, Drug development cost estimates hard to swallow, *Canadian Medical Association Journal*, *180*(3), 279–280 (2009).

[53] *See* 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, 1702 (1997).

[54] 35 U.S.C. §101 (2012) (setting forth the utility requirement).

[55] Bilski v. Kappos, 561 U.S. 593, 593-96 (2010).

[56] Section 101 is 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). As the Supreme Court stated in *Bilski*, "[f]or example, 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.' Bilski v. Kappos, 561 U.S. 593, 605 (2010) (*citing* Diamond v. Diehr, 450 U.S 175, 195 (1981) (STEVENS, J., dissenting)). But this fact does not mean that unforeseen innovations such as computer programs are always unpatentable. *Id*. (*citing* Diamond v. Diehr, 450 U.S 175, 192-93 (1981)

case of *Diamond v. Chakrabarty*, the Supreme Court was faced with deciding whether genetically modified organisms could be patented. The Court held that a categorical rule denying patent protection for "inventions in areas not contemplated by Congress... would frustrate the purposes of the patent law."[57] Under that reasoning, computer inventorship should not be prohibited based on statutory text designed to prohibit corporate inventorship. If computer inventorship is to be prohibited, it should only be on the basis of sound public policy.

There might be a reason to prohibit computer inventorship even under a strictly utilitarian analysis if patent protection is unnecessary to incentivize Computational Invention. In the software context, for example, some commentators, such as the Honorable Judge Richard Posner of the United States Court of Appeals for the Seventh Circuit, have argued that patents may be not be needed to provide adequate incentives.[58] In the software industry, unlike in the pharmaceutical industry, innovation is more often incremental, quickly superseded, less costly to develop, and innovators have a significant first mover advantage.[59] Computational Invention may develop due to incentives other than patent protection, and patents also create barriers to innovation. Put another way, the benefit of patents as an incentive for innovation may be outweighed by the costs of restricting competition. Yet whether that is the case as an empirical matter is a very difficult determination to make.

Hal would be less appropriate as an inventor under other intellectual property theories. While not enumerated in the Constitution, courts have justified granting patent monopolies on the basis of non-utilitarian policies.[60] For example, a Labor Theory or Lockean theory of patent protection holds that a person who labors upon resources unowned or "held in common" has a natural property right to the fruits of their labor.[61] Here, given that Hal is not a person, it would not be unjust for Hal's owner to appropriate its labor. Similarly, Hal's inventions do not deserve protection under a Personality Theory.[62] Hal's innovation is not performed to fulfill a human need, and Hal would not be offended by the manner in which its inventions were applied. Hal might even be a concerning recipient for inventorship under a Social Planning Theory which holds that patent rights should be shaped to help foster the achievement of a just and attractive culture.[63] A machine could innovate without a moral compass in ways that are detrimental to humans. However, because a computer will be owned by an individual or

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(STEVENS, J., dissenting).

[57] Diamond v. Chakrabarty, 447 U. S. 303, 315 (1980).

[58] WILLIAM M. LANDES & RICHARD A POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 11, 312 (2003).

[59] *See generally id*. at 312-13.

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

[61] *Id*.

[62] Tom G. Palmer, *Are Patent Rights and Copyrights Morally Justified? The Philosophy of Property Rights and Objects,* HARV. J.L. & PUB. POL'Y 817, 835-849 (1990), *available at* http://tomgpalmer.com/wp-content/uploads/papers/morallyjustified.pdf.

[63] Mohammad Amin Naser, *Computer Software: Copyrights v. Patents,* 8 LOYOLA LAW AND TECHNOLOGY ANNUAL 37, 41-43 (2009).

entity to whom an invention can be assigned, there would be an opportunity for a person to judge the morality of a patent before submitting it to the USPTO.[64]

Concluding Thoughts

For now, Computational Invention largely poses interesting theoretical questions. But in the not-too-distant future as machines and their functionality continue to evolve, and as computational creativity becomes common along with the use of big data, the issue of computer inventorship will need to be resolved. Whether patent law protects Computational Invention may have far-reaching effects on the development of the software industry and how innovation will occur in the future. Given its importance, there's a need for the USPTO, Courts, and Congress to give Computational Invention serious consideration.

[64] Though, some human inventors also appear to lack a moral compass. Cynthia M. Ho, *Splicing Morality and Patent Law: Issues Arising from Mixing Mice and Men* 2 WASH. U. J.L. & POL'Y 247, 247-285 (2000), *available at* http://openscholarship.wustl.edu/cgi/viewcontent.cgi?article=1509&context=law_journal_law_policy.