# Patents as Intellectual Credentials[i]

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***Abstract:*** Although patents and journal papers both contribute to "the edifice of knowledge," the full value of a patent as an intellectual credential is realized when, and only when, the patent is supplemented by other credentials that certify an inventor's ancillary skills. Such ancillary skills are those ideally taught in graduate school, and include conducting investigations according to accepted methodology, carrying written arguments logically from premises to conclusions, and relating new contributions to the existing body of knowledge.

## *Introduction*

Tradition supports the notion that peer-reviewed journal papers are the fundamental unit of accomplishment for scientists and research engineers. But what about patents? Should patents be accepted as the equal of journal papers in the construction of the edifice of knowledge? Although the answers may be primarily of interest to philosophers and university tenure committees, such questions bring to mind something more general: to what extent are patents meaningful as intellectual credentials? What do they say about their inventors? How should they be gauged when evaluating a portfolio that also includes other kinds of credentials?

## *The Scientist Writes a Journal Paper*

In principle, scientific discovery comes from deliberate investigation conducted according to the scientific method. The theoretical essence of the scientific method, as described by philosopher Karl Popper, is the construction and refutation of hypotheses.

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[i] This paper draws upon an earlier work: D. R. Irvin; "Recognizing Inventors as Contributors to Knowledge;" *Journal of the Patent and Trademark Office Society,* vol. 82, no. 10 (Oct. 2000), pp. 713-720

Hypotheses form in an investigator's mind as seemingly random permutations of relevant facts and principles. The investigator may reject most nascent hypotheses as being untenable, based on the outcomes of thought experiments. Those that survive the investigator's thought experiments are ready for further examination by model building, laboratory evaluation, mathematical analysis, computer simulation, and so forth. Those that pass this further examination graduate into the realm of tenable propositions developed according to the scientific method.

Hypotheses not refuted are not claimed to be proved; rather, they are admitted to the body of systematic knowledge through proper publication. Here, "proper" means subject to expert review, which certifies the contribution as being at least tentatively valid and original. This has practical importance, of course, because publication makes worthy findings available to other investigators, who may then incorporate the new knowledge into their own permutations in search of new hypotheses.

***Systematic Knowledge***

In a simple *ad hoc* model, useful here for discussion, the body of knowledge relevant to a field of investigation is *systematic* when:

(a) New facts and principles are developed according to accepted methods;

(b) Potential contributions are subject to expert review before being admitted, so that the body of knowledge may advance without the inclusion of errors, trivialities, and duplications;

(c) The facts and principles are preserved by archive and made readily accessible; and

(d) The facts and principles are indexed and related amongst themselves to provide order, with the use of citations having an important role.

### *The Inventor Works Much in the Same Way*

Maslow [1] describes invention as *"the sudden integration of previously known bits of knowledge not yet suitably patterned. The flash of discovery is most frequently the closure of a gestalt rather than the creation of something out of nothing – this is the moment of a-ha!"* experienced by both scientist and inventor. The inventor's mind ponders seemingly random permutations of unrelated, unlikely, and sometimes seemingly contradictory facts, principles, and observations, sorting through the possibilities and testing them by thought experiment until a plausibility emerges. Once the limits of the inventor's thought experiments are reached, a proposition that cannot be refuted by thought alone may be tested further, again for example by model building, by laboratory evaluation, by computer simulation, or by mathematical analysis. Thus, like scientific work, invention can be viewed as the creation and testing of hypotheses.

Beyond inventors' testing of hypotheses by one means or another, inventions are subject to external review before they reach the stage of patents. The first phase of review is often driven by economics. In contrast to the minimal expense of publishing journal papers, the preparation and prosecution of patent applications can be quite burdensome. In the United States, the process from beginning to end typically costs more than $10,000. The lifetime cost of a multi-country, international filing can top $100,000. The point here is that whoever suffers these expenses will make a serious effort to ensure that their money is at least reasonably well spent.

### *Formal Review – The Examination of Patent Applications*

The journey leading to a patent starts with the conception of an invention, as outlined above. Usually, the next steps are for the inventors to write an *invention disclosure* – an informal document describing their work – and to engage a patent attorney [2] to prepare a formal patent application from the invention disclosure and file it with the U.S. Patent and Trademark Office (USPTO).

The Patent Office classifies each incoming application by its technological species, and assigns an *examiner*. Examiners are specialists. They know their fields of technology, and are presumed to be fully competent by courts of law. An important part of an examiner's job is to determine whether a purported invention clears several thresholds, two of which are (1) the invention must be novel, meaning that the same thing has not already been done, and (2) the invention must not be obvious to those of ordinary skill in the art. The test for obviousness is neither explicitly defined nor straightforward. Rather, the question of obviousness is considered with reference to the USPTO's *Manual of Patent Examining Procedure,* which incorporates the body of pertinent case law (court decisions) and regulations.

In order to determine whether the purported invention clears these two thresholds, the examiner searches for *prior art*. Prior art comprises relevant teachings – patents, journal papers, textbooks, commercial offerings, and so forth – that predate the application under examination. In other words, the examiner looks for earlier work along the same lines. Based on the results of the search, the examiner then determines the patentability of each claim of the application under review, and communicates this to the attorney in a *first office action*. The first office action may allow all of the inventors' claims, or allow only a subset of the claims, or reject all of the claims.

The attorney, with the advice of the inventors, then responds to the examiner, either accepting the examiner's judgement or presenting a reasoned argument as to why the examiner has erred. The examiner replies to the attorney with another office action. This process can iterate through further cycles of examination if need be. *In essence, the patent examiner has the same role as the academic journal's editor and referees.*

### *The Invention Becomes a Contribution to Knowledge*

Once an invention clears the formal examination hurdle, a patent is granted, and the invention becomes an original contribution to knowledge in the same way that the

scientist's work becomes an original contribution to knowledge upon its publication. In particular, a granted patent satisfies the four criteria of the *ad hoc* model proposed earlier:

> (a) The contribution to knowledge offered by the invention has been developed according to accepted methodology – the same methodology as that of science – as described above: random permutation, hypothesis, and attempted refutation;
>
> (b) The contribution has been reviewed by an expert – a patent examiner – and normally by peers at the inventor's laboratory as well;
>
> (c) Archived publication makes the invention available to others working in the field – the patent literature is public, as suggested by the etymology of the word *patent*; an abstract is published in the *Official Gazette of the United States Patent and Trademark Office*; and
>
> (d) Forward and backward citations are recorded by the USPTO as they are encountered, thereby providing order.

The practice of crediting others' work by citation is required in the journal literature as a matter of ethics. In the patent literature, however, proper citation is required as a matter of law. Moreover, during the course of litigation, a party seeking to overturn a patent will search the literature thoroughly, looking for prior art that serves to invalidate the patent in question but which was not considered during its examination. Thus, it is good practice to ensure that all of the prior art that is material to the patentability of an invention be considered by the examiner. Beyond the aspects of good practice, an inventor and his or her attorney are required by law to disclose to the examiner everything that they know about the prior art that could reasonably be considered material to the invention's patentability. There is no legal requirement, however, that

either the attorney or the inventor do a deep search for prior art, or indeed any search at all. That responsibility falls on the examiner at the USPTO.

On its front page, each issued patent has a list of citations of works considered by the examiner. Generally, these fall into three categories: U.S. patent documents, foreign patent documents, and "other publications." The category "other publications" includes journal papers and commercial technical literature. Such citations are, of course, backward citations – the examiner looks back in time to identify earlier work that is material to the patentability of the invention under examination. Conversely, as patents are granted and enter the body of systematic knowledge, they become available as references to be cited during the examination of newer patent applications. Thus, a backward citation by a newer patent creates a forward citation of an older patent.

Forward citations counts are useful metrics of both the journal literature and the patent literature. In the case of journal papers, a high forward-citation count is important because it conveys prestige to a paper's authors, and serves as a rough approximation of the intellectual import of the paper as well as the authors' capability. High forward-citation counts are also important measures of patents, although for a different reason: as an approximation, a patent's economic value is proportional to its forward-citation count.[3]

To illustrate why the link between forward citations and economic value is important in a practical sense, consider, for example, a cross-licensing negotiation involving a 1000-patent portfolio. It would be virtually impossible to evaluate each patent individually. Clairvoyance would be needed to quantify the future value of each patent, and a deep bench of technical and legal expertise would be needed even to understand the portfolio. Instead, counting the number of forward citations provides a cost-effective way to gauge the portfolio's economic value.

As a benchmark, U.C. Berkeley Professor Bronwyn Hall cites data from her study published in the *Rand Journal of Economics* reporting that a substantial economic

premium accrues to portfolios that average more than 20 forward citations per patent. [4] According to another source, patents with more than 20 citations are more than three-times as likely to be involved in litigation than those with fewer than 20 citations [5] (which indicates considerable importance, given the enormous cost of litigation). For these and other reasons, a patent with at least 20 forward citations is generally thought to be "valuable" and "important." [6] Overall, the distribution of forward citations per patent is highly skewed, having the classic long tail of a Pareto (although the distribution is not exactly Pareto), wherein the mean value greatly exceeds the median.[7]

***The Quality of Peer Review and Patent Examination***

How does the quality of patent examination compare with the quality of peer review of journal papers? In practice, the review of journal papers – peer review – has turned out to be a rather loose filter. The present situation regarding low replication rates in many fields illustrates this. One problem is "forum shopping" – there are legions of academic journals, each with its own ideas about quality. Some may be called "predatory," concerning themselves only with economic profit. Another is "p-hacking," or the torture of data until it confesses to *something*. Yet another is the simple carelessness, gullibility, tribalism, and capriciousness occasionally exhibited by those who review journal papers. Consequently, peer review as practiced today could be thought of as helpful but not sufficient to ensure the integrity of the body of journal literature.

Perhaps the same may be said, *but only to a lesser extent*, of patent examination. The issue of "forum shopping" does not apply to patent applications in the United States: there is only one USPTO. Moreover, Patent Office examiners are educated specialists who devote their full-time efforts to vetting patent applications. The same kind of involvement cannot be attributed to the uncompensated volunteers who serve as referees for journals. Further, patent examiners are disinterested parties, whereas the volunteers who review journal papers may be in professional or ideological alliance, competition, or conflict with the authors whose work they vet.

Nevertheless, patents are occasionally granted for the trivial and even the absurd. There are, however, about 12 million US patents extant. There will be outliers in any data set this large. These may be called “false positives,” meaning that the examiners failed to weed-out some unworthy applications, and let them issue as patents. It’s difficult to determine what the fraction of false positives really is, because we can observe the characteristics of only the output of the end-to-end vetting process, without having adequate knowledge of the characteristics of the input. This is an example of survivor bias. We know only the cases that make it through the system; we have no knowledge of how many unworthy candidates are denied along the way.

Suppose, for example, that 990 of 1000 unworthy candidates were to pass examination and issue as patents. This would clearly indicate a problem with examination. On the other hand, suppose that only one of the 1000 unworthy candidates were to pass examination and issue as a patent. This “failure rate” of one-in-a-thousand would be excellent by reasonable human standards, yet would still result in about 12,000 “junk” patents. Unfortunately, junk patents inevitably draw the attention of the press, which sometimes leads uninformed critics to question the integrity of the examination process.

***The Analyst and the Synthesist***

In his famous 1959 Rede Lecture at Cambridge University, C. P. Snow identified two cultures –the literary and the scientific – and remarked: [8]

> *“I believe the intellectual life of the whole of Western society is increasingly being split into two polar groups. . . . Literary intellectuals at one pole – at the other scientists, and as the most representative, the physical scientists. Between the two a gulf of mutual incomprehension – sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding.”*

The same might be said, although clearly to a lesser extent, about inventors and journal authors. There is an inherent cultural difference between the patent literature, which

describes mostly the results of commercial research, and the journal literature, which describes mostly the results of academic research.[9] To some extent, journal papers may be thought of as being driven by analysis, whereas patents may be thought of as being driven by educated intuition.

Given this difference, the analyst might view the work of the synthesist as being somehow lesser, mistaking intuitive linkage with obviousness or triviality, especially when a product of intuition is not readily amenable to analysis. In the world of inventions and patents, however, the word "obvious" has particular meaning based on regulatory rulings and case law. Thus, as a practical matter, synthesists with granted patents may have a stronger argument than analysts in defending their work.

In the same Rede Lecture,[10] Snow continued on with the following hyperbolical thought, apropos but perhaps a bit unnecessarily harsh: [11]

> *Pure scientists have by and large been dim-witted about engineers and applied science. They couldn't get interested. They wouldn't recognize that many of the problems were as intellectually exacting as pure problems, and that many of the solutions were as satisfying and beautiful. Their instinct – perhaps sharpened in this country* [England] *by the passion to find a new snobbism wherever possible, and to invent one if it doesn't exist – was to take it for granted that applied science was an occupation for second-rate minds.*

***Inevitability and Obviousness***

Over the long run, most advances are inevitable, and sometimes even occur simultaneously among independent investigators. A nihilistic view might hold that the work of both scientists and inventors is therefore largely obvious, and is simply a consequence of the background. The question here turns on the word "obvious." In casual use, the word "obvious" means "easily perceived." Most facts and principles, *once discovered and explained*, are indeed easily perceived by an intelligent audience.

This does not mean that they are easily wrought, or that they can be timely wrought, or that their contribution to knowledge is somehow diminished.

***What a Patent is Not***

A post-graduate student who is a candidate for a research degree is required to submit an academic thesis. The thesis may be thought of as an extended journal paper or a "stapled" collection of journal papers of ordinary length. In this realm, *an original contribution to knowledge* is the sometimes-elusive attribute that separates a doctor's thesis from a master's. Beyond this, however, an academic thesis has other purposes: to demonstrate the candidate's ability to carry a written argument logically from premises to conclusions, command of the field of inquiry and its literature, skill in the use of scholarly apparatus, and so forth.[12]

The academic thesis thereby serves as a metaphor to illustrate what a journal paper is, and what a patent is not. A patent is not a demonstration of an inventor's ability to write or to carry an argument logically, as the manuscript itself is organized and written by an attorney. Further, a patent does not show that the inventor is aware of the prior art, or that the inventor can search the literature and place his or her work in context by way of citations. This is done by the patent examiner. Finally, a patent does not certify that the inventor is capable of testing hypotheses by experiment, mathematical analysis, or computer simulation, as the hypothesis may have been tested by thought alone, especially in predictable fields.[13]

In other words, although a patent certifies an inventor's creativity and original contribution to knowledge, it is not necessarily an overarching credential, whereas an academic thesis – and by extension a refereed journal paper – is both an original contribution to knowledge and a demonstration of the investigator's several other skills.

### *So Which is Better – A Patent or a Journal Paper?*

This is a silly question, of course, whose answer hinges on the particulars of which patent and which journal paper. The question, however, is intended to be rhetorical, and to draw attention to the important but immeasurable quality of *gravitas*. Clearly, patents such as Edison's on the light bulb or Bell's on the telephone far outweigh papers such as the one now at hand. Conversely, Einstein's brief paper on the photoelectric effect surely outweighs any number of patents on potato peelers and bottle-cap openers.

In addition to disseminating new knowledge, patents and journal papers may be said to share another common purpose – to claim and defend turf. A journal paper brings its authors reputational credit by certifying that *their* efforts have added a particular brick to the edifice of knowledge. Any economic reward likely comes by way of career advancement. A patent, on the other hand, stakes-out economic territory through the control of licensing rights. A coproduct of the patent is its contribution of another brick to the edifice, and the commensurate credit that such brings to the reputation of the inventors.

### *A Few Thoughts from Academia*

As mentioned earlier, university tenure-and-promotion committees often consider questions of the kind examined here. Along the same vein, some have published guidelines that put patents into perspective. Four such examples are discussed below, followed by a fifth from a different kind of organization.

The first example comes from Washington State University's Voiland College of Engineering.[14] Their approach is to divide accomplishments of research into two tiers. The higher tier includes peer-reviewed research papers and issued patents, with papers accorded the highest status within this tier. The lower tier includes books, book

chapters, and invited presentations. Thus, patents are "ranked" below journal papers, but clearly above books and chapters.

The second example comes from Louisiana Tech University, which has the following to say about patents: [15]

> *"The filing of a patent resulting from an engineering or scientific research project is certainly evidence of a candidate's* [for promotion or tenure] *creativity. Patents are often the result of an extensive applied research effort, and in some cases, basic research. The patent is evidence that the candidate was able to successfully apply scientific and engineering principles to the solution of a problem or to satisfy a societal need. Due to proprietary and legal restrictions, the candidate is often prohibited from immediately publishing the work which led to the development of the patent. In such cases, the patent may serve as the only evidence of the candidate's scholarly activity in this regard. The candidate should include in the dossier evidence of the scientific quality of a patent, perhaps in a letter from independent outside sources."*

Note four aspects of this example: (1) the inventive process is referred to as "scholarly activity," (2) a patent may exhibit "scientific quality," (3) evidence of "the scientific quality of a patent" is solicited, presumably to weed-out the patents on potato peelers and bottle-cap openers, and (4) a patent is acceptable as a stand-in for a delayed journal publication.

The third example comes from West Texas A&M University.[16] Their approach is to assign numerical points to various kinds of intellectual contributions (their term), and to use a candidate's point total as a metric for judging promotion or tenure. In the A&M system, the following are assigned four points each: "Major contributor to a peer reviewed publication in a discipline appropriate journal," and "Major contributor to a respectable discipline appropriate patent award." Here, the patent and the journal paper are treated as equals.

The fourth example comes from a small, liberal arts college in Massachusetts, Stonehill College. Their chemistry department simply notes that "We consider peer-reviewed publications and patents to be the final measure of successful scholarship."[17]

The final example comes from a different kind of organization – *Sigma Xi, The Scientific Research Honor Society*. Their criteria for full membership are:[18]

> "*An individual who has shown noteworthy achievement as an original investigator in a field of pure or applied science is eligible for election to Full Membership. / This noteworthy achievement must be evidenced by publication as the primary author (defined in the manner appropriate to the discipline) on at least two different articles published in a refereed journal, patents, or refereed monographs. / Dissertations and theses alone are not considered sufficient for demonstration of this achievement and must be accompanied by at least two other publications."*

Note here that an applicant's portfolio is evaluated holistically rather than its individual components, wherein (1) patents and journal papers are assumed *a priori* to be equals, and (2) both patents and journal papers are identified as "publications." Full membership, however, further requires sponsorship and election by members (vetting). One trusts that the vetting weeds-out any potato-peeler patents offered by candidates for admission.

### *Multiple Authors and Inventors*

Further complicating the situation, multi-author papers and multi-inventor patents have become commonplace. A seemingly routine practice is for a journal paper to list a plethora of authors, of which only a few may have actually contributed anything of intellectual substance. Various ways have been proposed to apportion credit realistically in these situations. Some assign more credit to sole-author papers than to multi-author papers. In the case of multi-author papers, credit is sometimes awarded in

what might be called “fractional units,” with the first author receiving the lion’s share. In some cases, citation counts and journal prestige are also taken into consideration.

The situation for patents is more straightforward. Inventors may as well be listed alphabetically as in any other order. Each person listed as an inventor on a granted patent must have contributed to the intellectual conception of the invention – there is no differential endorsement of a “first inventor” in any meaningful sense. Conversely, someone who works solely as a technician who reduces an invention to practice or works only as a scribe to “write things up” cannot legitimately claim inventorship. Getting this right is important, because a patent reporting spurious inventorship can be found invalid in litigation.

***Concluding Remarks***

Patents and journal papers share a common purpose: to disseminate new knowledge. In creating this new knowledge, inventors and scientists work in much the same way, developing and testing hypotheses, looking for a sound hypothesis that withstands refutation, subjecting the result to expert review, and publishing in an open, cumulative literature. Although the patent and the journal paper differ significantly, they are equally original contributions to systematic knowledge.

Nevertheless, a journal paper might be viewed as a broader credential than a patent for at least two reasons: (1) a journal paper is primarily the work of its authors, whereas a patent is the work of the inventors, a highly-skilled attorney, and a patent examiner, and (2) because of the involvement of these other parties, a patent *per se* does not certify an inventor’s competence with written expression, logical argument, the tools of scholarship, command of the related art or literature, and so forth. In other words, a journal paper is a more encompassing credential than a patent. But given the apparent weakness of journal-paper review and the comparative strength of patent examination, it may be fair to say that a patent is a deeper, more reliable credential than a journal paper.

This leads to a final “it all depends” situation. If an inventor has published in a primary journal (or written an academic thesis), this certifies the inventor’s competence in the academic skills mentioned above. The inventor has “checked this box.” Thus, for an inventor who has a record of primary journal publication, *and perhaps only for such an inventor*, patents may be accorded full status as the equals of journal papers in a holistic evaluation of his or her portfolio, based on the patents’ original contributions to systematic knowledge combined with the journal papers’ certification of the inventor’s other skills.

In other words, what a patent says about an inventor – its value as an intellectual credential – depends on what else the inventor brings to the table, whereas a journal paper stands independently.

***Biographical Note:*** David Rand Irvin was admitted to practice before the United States Patent Office as an agent in 1998. In recognition of his earlier work as a research engineer, he was honored by the Ericsson laboratory at Research Triangle Park, NC, with the Master Inventor's Award, having received 45 US patents (cited about 2500 times) and 93 foreign patents. As a patent agent, he has worked in various ways with more than 2000 invention disclosures. David is a graduate of Johns Hopkins University (*Phi Beta Kappa*), North Carolina State University (National Science Foundation trainee), and the University of Wisconsin at Madison.

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[1] Abraham H. Maslow, *Maslow on Management*; John Wiley & Sons, Inc.; New York, 1998; p.231

[2] Patent attorneys are required to have earned at least the educational equivalent of a bachelor's degree in engineering or science in addition to a law degree. Many have earned advanced degrees in technical fields; more than a few have earned doctorates. Further, patent attorneys often acquire significant technical competence over the course of specialized practice. Thus, they are able to help an inventor focus on the nub of an invention, and sometimes contribute (without recognition) to its technical aspects. Additionally, ethical attorneys often discuss the likelihood of gaining a patent with their clients, thereby providing an additional stage of vetting, albeit quite informal.

[3] Bronwyn H. Hall, *Patent Data as Indicators*, slides presented to the World Intellectual Property Organization (WIPO), October, 2004; taken from Hall, Adam Jaffe, and Manuel Trajtenberg, "Market Value and Patent Citations," *Rand Journal of Econ*omics, Vol. 36., No. 1 (Spring 205), pp.16-38. A pre-print is available at https://eml.berkeley.edu/~bhhall/papers/HallJaffeTrajtenberg_RJEjan04.pdf

[4] *ibid.*

[5] "The Importance of Patent Citation Statistics in Research," Patent PC (a law firm), Santa Clara, California; https://patentpc.com/blog/the-importance-of-patent-citation-statistics-in-research

[6] See, for example, C.L. Benson and C. L Magee, "Quantitative Determination of Technological Improvement from Patent Data," PLoS ONE 10 (4):e0121635. Doi:10.137/jopurnal.pone.o121635; https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0121635

[7] A substantial fraction of all issued patents receive no forward citations at all; the median value seems to be one forward citation per patent; the mean value hovers below 10 forward citations per patent due to the distribution's long tail; and 0.01% receive more than 100 forward citations. The exact values of these parameters depend on the field of invention, the time period covered by the study reporting the numbers, and the way in which time-period truncation is factored in for patents that have not yet fully matured.

[8] C. P. Snow, *The Two Cultures and the Scientific Revolution*, Cambridge University Press, New York, 1961 pp. 4-5

[9] J. J. Gilman in "Research management today," *Physics Today,* March 1991, pp.42-48

[10] The yearly Rede Lectures at Cambridge began in the 18th century, and have continued yearly from the 19th century through the present time. See: *The Rede Lecture at Cambridge*. *Nature* **5**, 9 (1871). https://doi.org/10.1038/005009a0

[11] *op cit.,* Snow, p 32

[12] As proposed by Paul E. Koefod throughout *The Writing Requirements for Graduate Degrees*, Prentice-Hall, Inc., Englewood Hills, NJ, 1964

[13] American jurisprudence admits the possibility that an invention, particularly an uncomplicated one, may indeed be fully understood by thought alone. These fields are called *predictable*, meaning that anyone with relevant skill would be able to understand and predict the behavior of the inventive configuration, *in retrospect*, by applying known principles. In this sense, mechanical and electrical inventions may be predictable, whereas biological and chemical are generally not.

[14] *Supplementary Procedures and Criteria for Tenure and Promotion*, Voiland College of Engineering and Architecture, Washington State University, 27 Oct. 2015; https://vcea.wsu.edu/faculty-staff/documents/2016/01/tenure-and-promotion-guidelines-vcea.pdf/

[15] *Tenure and Promotion Guidelines*, College of Engineering and Science, Louisiana Tech University, July 2021; https://coes.latech.edu/documents/2022/08/tenure-and-promotion-guidelines.pdf/

[16] *Standards for Tenure and Promotion*, College of Engineering, West Texas A&M University; revised 1 June 2021; https://www.wtamu.edu/_files/docs/academics/academic-affairs/TP%20Standards%20COE66.pdf

[17] *Scholarship Criteria for Tenure and Promotion*," Chemistry Department, Stonehill College; https://stonehill-website.s3.amazonaws.com/files/resources/scholarship-criteria-booklet-august-2020-ac.pdf

[18] "Becoming a Member;" *Sigma Xi, The Scientific Research Honor Society*; https://www.sigmaxi.org/members/becoming-a-member (2024)